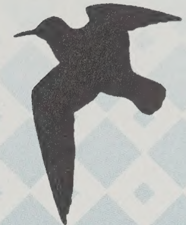
# Atlas of Nearctic shorebirds and other waterbirds on the coast of Panama



Canadian Wildlife Service
Special Publication

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Environment Canada | Environnement Canada
Canadian Wildlife Service | Service canadien de la faune

Canada

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**Abstract**

This Atlas presents the results of aerial surveys undertaken to determine the principal areas used by Nearctic shorebirds and other species of waterbirds on wintering grounds on the coast of Panama. Additional information is presented on numbers and distributions of these groups of birds on the coast of the Golfo de Panama during migration periods. Surveys of wintering populations were carried out in January 1993, and surveys of populations present during southward and northward migration periods were conducted in October 1991 and February 1988, respectively.

In January 1993, some 255 000 Nearctic shorebirds were counted in Panama, of which the majority (254 000, 99.8%) were found on the Pacific coast. Small shorebirds (mostly Western Sandpipers *Calidris mauri*) were numerically dominant, making up 236 000 (92.8%) of the total, with medium-sized (12 300, 4.8%) and large (6200, 2.4%) species present in smaller numbers. The most important areas for shorebirds were found around the Golfo de Panama, especially the coast east of Panama City, the mudflats around Golfo de San Miguel in the east of the gulf, the intertidal flats and wetlands surrounding Bahia de Parita in the west of the gulf, and parts of the coast between Bahia de Chame and Panama City. Smaller concentrations of shorebirds occurred in the Golfo de Montijo, as well as on the beaches and intertidal inlets along the Golfo de Chiriqui in the west of the country. The most important habitats involved a combination of mudflats backed by mangrove forests. Similar results were obtained for other groups of waterbirds, including coastal seabirds, wading birds, and birds of prey.

Highest numbers of shorebirds were found in the Golfo de Panama on surveys carried out during the period of southward migration in October 1991, when a total of over 369 000 shorebirds was counted; this compared with totals of 185 000 Nearctic shorebirds during northward migration in February 1988 and of 247 000 in the gulf during the wintering period in January 1993. In contrast, some species of coastal seabirds were at their highest numbers in February 1988, at a time when coastal upwelling occurs.

**Résumé**

Cet Atlas présente les résultats de relevés aériens entrepris pour déterminer les principales zones visitées par les oiseaux de rivage néartiques et d'autres espèces d'oiseaux aquatiques dans les zones d'hivernage de la côte de Panama. Des renseignements supplémentaires portent sur le nombre et la distribution de ces groupes d'oiseaux sur la côte du golfe de Panama, durant les périodes de migration. Des relevés des populations hivernantes ont été exécutés en janvier 1993 et les relevés des populations présentes durant la période de migration, vers le sud et vers le nord, ont été réalisés respectivement en octobre 1991 et en février 1988.

En janvier 1993, quelques 255 000 oiseaux de rivage néartiques ont été dénombrés au Panama, parmi lesquels une majorité (254 000 ou 99,8 %) ont été observés sur la côte du Pacifique. Les petits oiseaux de rivage (principalement le Bécasseau d'Alaska *Calidris mauri*) dominent en nombre, totalisant 236 000 (92,8 % du total); les oiseaux moyens étaient au nombre de 12 300 (4,8 %) et les grosses espèces, 6 200 (2,4 %), étaient en plus petit nombre. Les principales zones où les oiseaux de rivage ont été observés se trouvaient autour du golfe de Panama, particulièrement la côte est de Panama City, dans les vasières entourant le golfe de San Miguel, à l'est du golfe, les plaines intertidales et les terres humides entourant Bahia de Parita, à l'ouest du golfe, et certaines zones côtières entre Bahia de Chame et Panama City. De plus petites concentrations d'oiseaux de rivage ont été observés dans le golfe de Montijo, de même que sur les plages et dans les baies intertidales, le long du golfe de Chiriqui à l'ouest du pays. Les habitats les plus importants comprenaient une combinaison de vasières et de mangroves. Des résultats similaires furent obtenus chez d'autres groupes d'oiseaux aquatiques, y compris des oiseaux de mer littorale, des échassiers et des oiseaux de proie.

La majorité des oiseaux de rivage se trouvaient dans le golfe de Panama selon les relevés réalisés durant la période de migration vers le sud en octobre 1991, alors qu'un total de plus de 369 000 oiseaux de rivage ont été dénombrés; comparativement avec des totaux de 185 000 oiseaux de rivage néartiques durant la migration vers le nord en février 1988 et de 247 000 dans le golfe durant la période d'hibernation, en janvier 1993. Par contre, certaines espèces d'oiseaux de mer littorale étaient en plus grand nombre en février 1988, au moment où se produit la remontée côtière.

**Resumen**

El Atlas presenta los resultados de los estudios aéreos realizados con el fin de determinar las principales áreas utilizadas por playeros del Neártico, al igual que otras aves acuáticas que invernan en el territorio panameño. Se brinda información adicional sobre cantidades y distribución de éstos a lo largo de la costa del golfo de Panamá durante los períodos de invernación. Los estudios de las poblaciones invernantes se efectuaron en Enero de 1993 y, los de poblaciones presentes en dichos sitios durante la temporada de paso de éstos hacia el Sur o Norte fueron desarrollados en octubre de 1991 y febrero de 1988, respectivamente.

En enero de 1993 fueron detectadas unos 255 000 playeros en dicho territorio, de los cuales la mayoría (254 000, 99.8%) se ubicaron en la costa pacífica panameña. Los playeros pequeños (representados mayormente por el correlimos occidental *Calidris mauri*) fue numéricamente el más abundante, estando por encima de los 236 000 individuos (92.8% del gran total); los playeros de tamaño mediano (12 300 aves, 4.8%) al igual que los playeros grandes (6 200 aves, 2.4%) estuvieron representadas en números pequeños. Las áreas más importantes para playeros fueron detectadas hacia el Golfo de Panamá, y más específicamente hacia la costa oriental de la Ciudad de Panamá al igual que en los lodazales intermareales del Golfo de San Miguel — en el este del golfo; también son importantes las zonas intermareales y marismas que circundan la Bahía de Parita — en el occidente del Golfo, y las zonas vecinas a los manglares de la Bahía de Chame y la Ciudad de Panamá. Pequeñas concentraciones de playeros fueron ubicadas en el Golfo de Montijo, así como en las pequeñas zonas intermareales y estuarinas del Golfo de Chiriquí, hacia el occidente del país. Los hábitats más importantes son aquellos asociados a lodazales o limos adyacentes a los manglares costeros; similares resultados fueron obtenidos para otros grupos que incluyen aves acuáticas, marinas, costeras, aves vadeadoras y aves de rapiña.

Los estudios desarrollados durante el período de paso de migrantes del Norte — en octubre de 1991, señalan que el mayor número de ellos se ubican en el Golfo de Panamá, con un número superior a los 369 000 playeros, en contraste con el total de 185 000 aves registradas en febrero de 1988 durante su regreso al Norte procedentes de Sudamérica y; con el gran total de 247 000 registradas como invernantes en el Golfo de Panamá para enero de 1993. En contraste con estos resultados, algunas especies marinas alcanzaron su mayor número en febrero de 1988, período en que ocurre el afloramiento del Golfo de Panamá.

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## Organization of the Atlas

The background and development of distributional studies of shorebirds on an international scale are outlined in Chapter 1. Methods used during the aerial surveys themselves and for processing the data gathered are described in Chapter 2. Chapter 3 presents an overview of the geography, oceanography, and climate of Panama, while a description of the coastline and its habitats is presented in Chapter 4. The main results of the work, describing the distribution and abundance of shorebirds on the coast of Panama, is presented in Chapter 5, with a similar account for coastal seabirds, wading birds, and birds of prey in Chapter 6. The influence of the important phenomenon of oceanic upwelling on the distribution of birds and their use of coastal habitats is explored in Chapter 7. The major conclusions and their conservational implications are summarized in Chapter 8.

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# *Chapter 1*
# Introduction

R.I.G. Morrison, R.W. Butler, and R.K. Ross

## 1.1 Shorebirds and other waterbirds: distributional studies and conservation

Shorebirds are one of the most highly migratory groups of birds in the world. In the Western Hemisphere, many species of Nearctic shorebirds make long migrations between northerly breeding areas and more southerly "wintering" grounds, some species migrating from the Canadian Arctic to the most southerly parts of South America in Tierra del Fuego (Morrison 1984; Morrison and Ross 1989). Shorebirds are thus one of the most important groups of birds to be shared internationally, and their conservation can be successful only if approached on a cooperative, international basis.

One of the most basic and important pieces of information required for conservational planning is an understanding of the distribution of the birds at different times of the year — and hence the ability to identify those areas that are of critical importance to the birds during their annual migrations. Over the past 20 years, enormous advances have occurred in our understanding of shorebird distribution on an international scale (Morrison 1992). Starting in the 1970s, volunteer survey projects — such as the Maritimes Shorebird Survey, organized by the Canadian Wildlife Service in the Atlantic provinces of Canada, and the International Shorebird Survey, organized by the Manomet Bird Observatory, Massachusetts, for sites in the eastern United States and Latin America — provided information on shorebird distribution over wide areas of eastern North America. Ground and aerial surveys by biologists produced information from other, often more remote regions, including James Bay and the St. Lawrence estuary in Canada (Morrison 1983, 1984; Morrison and Myers 1989). Between 1981 and 1986, Morrison and Ross (1989), of the Canadian Wildlife Service, identified many of the major wintering areas used by Nearctic shorebirds in South America during a series of aerial surveys of the entire continent, conducted in collaboration with biologists from the countries concerned.

A key finding to emerge from these studies was that many coastal species of shorebirds concentrate at various sites to a marked degree, both on migration and on wintering areas. This concentration makes their populations, although numerous, highly vulnerable to local environmental perturbations. Many species appeared to depend on a series, or network, of sites to complete their annual migrations; for conservation to be successful, the entire network would need to be preserved. These insights led directly to the concept of forming a network of reserves to protect the key areas throughout the migration ranges of the various species (Morrison 1983, 1984), the idea becoming known as the Western Hemisphere Shorebird Reserve Network, or WHSRN (Myers et al. 1987a, 1987b). The idea became a reality in 1985 with the formation of the WHSRN organization. Since then, WHSRN has established a highly successful conservation program, with some 31 reserves in seven countries, stretching from Tierra del Fuego to Alaska, and protecting an estimated 10 million hectares of habitat and 30 million shorebirds (Wetlands for the Americas 1994; Morrison et al. 1995). WHSRN has continued to develop as an organization and to contribute to international wetland conservation. In 1991, it evolved into, but remained a distinct program within, Wetlands for the Americas, which has since joined forces with the International Waterfowl and Wetlands Research Bureau (IWRB) in Europe and the Asian Wetland Bureau (AWB) in the Far East to become part of a global initiative, Wetlands International, to promote the conservation of wetlands.

Further large-scale distributional studies of shorebirds have continued and are providing the information needed for conservational planning and for the expansion of the WHSRN (Gill et al. 1994). The Canadian Wildlife Service has conducted "Atlas" projects in Mexico (Morrison et al. 1992, 1993, 1994) and in Panama (Butler et al. 1992; this volume). Further information on shorebird sites in Mexico has come from ground and aerial surveys conducted by Harrington (1992, 1993, 1994) and Page (Page and Palacios 1993), and the volunteer Pacific Flyway Project conducted by Point Reyes Bird Observatory in California has provided information from sites on the Pacific coast of North America (Page et al. 1992). Broader inventories of wetlands in the Neotropical region have also contributed to the identification of key shorebird and waterbird sites (Scott and Carbonell 1986).

The conservation of sites used by large numbers of shorebirds also secures habitats used by other fauna. During the shorebird surveys, we observed large numbers of coastal seabirds, wading birds, and birds of prey, and information on these groups was also recorded during the flights. This has enabled us to compare the coastal distributions of shorebirds and other waterbirds with their habitats (Butler et al. 1997a) and in relation to coastal upwelling (Chapter 7). This Atlas thus goes beyond the scope of previous shorebird atlases

(Morrison and Ross 1989, see above) to examine the associations of birds with their habitats.

## 1.2 The Panamanian Shorebird Atlas Project

Panama is known to contain a number of internationally important wetlands, both along its coast and inland (Delgado 1983, 1986). Little detailed information, however, has been available on the status of Nearctic shorebirds in Panama, although especially significant numbers were thought to occur east of Panama City in the Bahia de Panama (Delgado 1986), where they share coastal habitats with large numbers of wading birds (Butler et al. 1992). The Canadian Wildlife Service Pacific and Yukon Region launched studies of the population ecology of the Western Sandpiper *Calidris mauri* in Panama in 1988. Since then, a body of information has been gathered describing the migration routes (Butler et al. 1996) and migration energetics (Butler et al. 1997b) of the species. The Canadian Wildlife Service Panamanian Shorebird Atlas Project was undertaken to identify key wintering areas used by shorebirds and other birds on both the Pacific and Caribbean coasts of Panama and involved a series of aerial surveys of some 3050 km covering almost all parts of the coast in January 1993. The surveys provided the opportunity to gather information on the coastal distribution of wading birds, about which relatively little is known in Central America (Hafner et al. 1997). In addition, aerial surveys of the coastline of the Golfo de Panama were carried out during February 1988 and October 1991 to determine numbers and distributions of shorebirds and other birds during northward and southward migration periods, respectively. The project was undertaken under the Canadian Wildlife Service Latin American Program, which was established in 1980 to support projects of conservational interest involving groups of birds shared between Canada and Latin American countries.

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# *Chapter 2*
# Methods

R.K. Ross and R.I.G. Morrison

## 2.1 Aerial survey procedures

Aerial surveys of coastal birds were carried out along the entire coastline of Panama between 14 and 18 January 1993. In addition, surveys of the coastline of the Golfo de Panama were conducted on 24–25 February 1988 to determine numbers present during the spring migration/late winter period and on 22–24 October 1991 to determine numbers present during the southward migration period. Shorebirds were the principal focus of the surveys, although observations were also made of coastal seabirds, wading birds, and birds of prey. Information on flight itineraries, aircraft used, and survey conditions is shown in Table 2.1. Common and scientific names of birds recorded during the surveys are shown in Table 2.2.

The survey procedure followed that used in other surveys of wintering shorebirds in South America and Mexico (Morrison and Ross 1989; Morrison et al. 1992, 1993, 1994). Surveys were conducted from single-engined, high-winged Cessna aircraft flying at 40–50 m above ground level and at 160–220 km/h, depending on bird numbers, habitat, and flight path circuitousness. The flights followed a path approximately 25 m offshore from the water's edge, with two observers (RIGM and RKR) looking inland from the copilot's seat and the seat behind, respectively; the bulk of the birds seen on the surveys occurred on this side of the aircraft. All observations were recorded directly onto audio tape cassettes for later transcription. The third observer (FSD) watched from the other side of the aircraft, counting those birds that moved offshore as well as recording descriptions of habitats occurring both along the shoreline and inland. Every effort was made to obtain complete coverage of all shoreline habitat suitable for coastal birds, including lagoons, shrimp ponds, and saltflats. Where possible, surveys were timed to occur near high tide, when birds tend to concentrate on feeding or roosting sites. Flights were carried out between 07:30 and 18:20 local time, and care was taken to choose survey directions that reduced effects of glare during times of low sun angle. On the Pacific coast, efforts were made to fly surveys in the morning in order to avoid the stronger winds and turbulence that tend to develop in the afternoon. Windy conditions were encountered on several afternoon flights but were not severe enough to affect the survey results.

Numbers of birds were determined by direct counting when the flocks were small or by visual estimation when larger concentrations were encountered. Identifications were made at the species level wherever possible. Where specific identification was not practicable owing to species similarities, viewing conditions, or size and diversity of flocks being encountered, birds were assigned to broader groupings (see Table 2.2 for species included in each group and category). Flocks consisting principally of small sandpipers were generally recorded as "peeps," which ground observations indicated were mostly Western Sandpipers *Calidris mauri*. Sanderlings *C. alba* could generally be distinguished from the air owing to their characteristic appearance and habitat use. Medium-sized species could usually be identified, given good light, moderate-sized flocks, and a slow survey speed, although Lesser Yellowlegs *Tringa flavipes* and Greater Yellowlegs *T. melanoleuca* were generally recorded simply as "yellowlegs." Most observations of "dowitchers" on coastal mudflats are likely to refer to Short-billed Dowitchers *Limnodromus griseus*, as this species is much more common than the Long-billed Dowitcher *L. scolopaceus*, which tends to be found in small numbers in freshwater habitats (Ridgely and Gwynne 1989). Large species were normally identifiable from the air.

Ground truthing operations to determine the accuracy of counts were not undertaken, as it was considered impracticable to reach many of the areas where large numbers of birds were found and doubtful whether appropriate correction factors could be developed for the variety of counting conditions encountered on the surveys. Comparison of counts between observers indicated a generally high degree of consistency. Numbers recorded on the surveys may be regarded as representing minimum numbers of birds likely to be found in an area, although the relationship between recorded numbers and absolute numbers on the ground remains undetermined. Survey methodology and personnel (RIGM and RKR) were the same as those employed on surveys of the coastlines of South America (Morrison and Ross 1989) and Mexico (Morrison et al. 1992, 1993, 1994), to ensure that data collected in all areas were as comparable as possible.

The aircraft's position throughout the survey was determined through onboard Global Positioning System (GPS) navigation equipment and by regular time checks at and between known landmarks. For this Atlas, the shoreline was divided into 107 segments based on landmarks and reasonably homogeneous habitat content (see Chapter 4, Map 4 Index).

**Table 2.1**
Summary of information on aerial surveys along the coast of Panama

| Date | Aircraft | Time | Coverage (sectors) | Tide | Weather |
|---|---|---|---|---|---|
| (a) Surveys of entire coast of Panama, January 1993 (Observers: RIGM, RKR, FSD) | | | | | |
| 14 January | Cessna 172 | 0810–0930 | 55–62 | High | Clear, calm, 25°C |
| | Cessna 172 | 1020–1115 | 52–54 | Moderately high | Light hazy overcast, calm, 25°C |
| 15 January | Cessna 206 | 0740–0845 | 64–70 | High | Light hazy overcast, light north wind, 25°C |
| | Cessna 206 | 0910–1050 | 71–86 | High | Cloudy except clear at south end of Peninsula de Azuero, calm, 25°C |
| 16 January | Cessna 206 | 1250–1415 | 35–49 | N/A: little tidal range | High thin overcast becoming clear, light north wind, 30°C |
| 17 January | Cessna 206 | 1100–1315 | 1–23 | N/A: little tidal range | Clear, moderate north wind, 35°C |
| | Cessna 206 | 1540–1645 | 25–34 | N/A: little tidal range | Broken cloud, moderate north wind, 30°C |
| 18 January | Cessna 206 | 1210–1410 | 87–104 | High | Clear, strong north wind, 30°C |
| | Cessna 206 | 1430–1435 | 106 | Moderately high | Clear, strong north wind, 30°C |
| (b) Surveys of coastline of Golfo de Panama, February 1988 (Observers: RIGM, RKR, FSD) | | | | | |
| 24 February | Cessna 172 | 1200–1820 | 64–71 | Moderately high | Moderately cloudy, strong winds |
| 25 February | Cessna 172 | 0730–1055 | 55–62 | High | Partially cloudy, light wind |
| (c) Surveys of coastline of Golfo de Panama, October 1991 (Observers: RIGM, RB, FSD) | | | | | |
| 22 October | Cessna 172 | 1115–1410 | 55–62 | High | Partially cloudy, light wind |
| 24 October | Cessna 172 | 0920–1620 | 64–71 | High | Partially cloudy, strong wind |

**Table 2.2**
Categories, groups, and principal species of birds observed during aerial surveys of the coast of Panama

| Category | Group | Principal species | |
|---|---|---|---|
| Shorebirds | Small | Spotted Sandpiper | *Actitis macularia* |
| | | Sanderling | *Calidris alba* |
| | | Unidentified small shorebirds (mostly Western Sandpipers) | *Calidris* spp. (mostly *Calidris mauri*) |
| | Medium-sized | Black-bellied Plover | *Pluvialis squatarola* |
| | | Killdeer | *Charadrius vociferus* |
| | | Yellowlegs spp. | *Tringa melanoleuca* and *T. flavipes* |
| | | Ruddy Turnstone | *Arenaria interpres* |
| | | Dowitcher spp. | *Limnodromus* spp. |
| | | Unidentified medium-sized shorebirds | |
| | Large | American Oystercatcher | *Haematopus palliatus* |
| | | Black-necked Stilt | *Himantopus mexicanus* |
| | | Marbled Godwit | *Limosa fedoa* |
| | | Willet | *Catoptrophorus semipalmatus* |
| | | Whimbrel | *Numenius phaeopus* |
| | | Unidentified large shorebirds | |
| Coastal seabirds | Pelican | Brown Pelican | *Pelecanus occidentalis* |
| | Cormorant | Neotropic Cormorant | *Phalacrocorax brasilianus* |
| | Frigatebird | Magnificent Frigatebird | *Fregata magnificens* |
| | Gulls | Unidentified gulls (many Laughing Gulls) | *Larus* spp. (many *Larus atricilla*) |
| | Terns | Unidentified terns | *Sterna* spp. |
| | Large terns | Unidentified large terns (mostly Royal Terns) | *Sterna* spp. (mostly *Sterna maxima*) |
| Wading birds | Heron: large white | Great Egret | *Ardea alba* |
| | Heron: large dark | Great Blue Heron | *Ardea herodias* |
| | Egret: small white | Snowy Egret | *Egretta thula* |
| | | Little Blue Heron (immature) | *Egretta caerulea* |
| | Heron: small dark | Little Blue Heron | *Egretta caerulea* |
| | Night-Heron | Black-crowned Night-Heron | *Nycticorax nycticorax* |
| | | Yellow-crowned Night-Heron | *Nycticorax violaceus* |
| | Others | Wood Stork | *Mycteria americana* |
| | | White Ibis | *Eudocimus albus* |
| | | Roseate Spoonbill | *Ajaia ajaja* |
| Birds of prey | | Osprey | *Pandion haliaetus* |
| | Vulture | Black Vulture | *Coragyps atratus* |
| | Caracara | Crested Caracara | *Polyborus plancus* |
| | Falcon | Peregrine Falcon | *Falco peregrinus* |
| | | Unidentified bird of prey | |

## 2.2 Data analysis

Bird totals were generated for each segment as follows:

- For shorebirds, counts obtained by the two observers on the right-hand side of the aircraft were compared and the larger values selected for each species and/or size group. Differences in counts may result when an observer was temporarily involved in navigation, photography, or equipment checks. These values were then added to any counts made by the observer on the left-hand side.
- For other species, duplicate counts were not made by the observers on the right-hand side, who instead divided the species and/or groups between themselves for counting. Totals from the two sides of the aircraft were simply added.

Numbers in the tables are unaltered survey data. In the text, numbers have usually been rounded as follows: 0–100, unchanged; 101–1000, to nearest 10; 1001–100 000, to nearest 100; and >100 000, to nearest 1000. Percentages were calculated using unrounded numbers.

Length of shoreline in each sector was measured on 1:500 000-scale aeronautical charts, and linear densities of birds were calculated by dividing numbers by sector length. Using each sector as a sample, comparisons were made of species densities among habitats using Kruskal-Wallis tests and associated multiple range tests (Zar 1984). Statistical tests were carried out using SAS (SAS Institute, Inc. 1988) or STATISTICA (Statsoft, Inc. 1995) software.

## 2.3 Habitat descriptions

Simple qualitative habitat descriptions were recorded for each survey sector (see Chapter 4). The descriptions in Table 4.1 in Chapter 4 are divided into two or three segments by diagonal strokes: each segment represents different zones occurring perpendicular to the shoreline. The first segment describes the major intertidal habitats along the shoreline in which the shorebirds usually occurred. The second segment describes the habitats occurring immediately behind the intertidal zone. Where necessary, a third segment lists habitats occurring farther inland, where they differ substantially from those on the shoreline. Within each survey sector, a variety of habitats usually occurred, and these are listed for each segment in decreasing order of dominance.

## 2.4 Map production

Maps were produced using MapInfo software (MapInfo Corp. 1994) and were based on 1:1 000 000-scale American Digital Cartography (ADC) WorldMap for MapInfo digital charts (ADC Inc. 1993). Information illustrating geographical features, such as elevation, was taken directly from appropriate layers on the Panama map on the ADC WorldMap Disc 1 (North America). Text, symbols, and other information were added to the maps as required using the editing facilities within MapInfo. Maps of bird distribution were produced from an outline map of Panama on which survey sectors and other appropriate information were marked. The coordinates of the midpoint of each survey sector were determined; for each species, an appropriately sized symbol, selected from a graduated sequence of circles chosen to cover the range of numbers of birds observed on the surveys, was plotted automatically at the midpoint of each sector from a computerized database.

## 2.5 Limitations of the data

Data obtained on the surveys were collected over a relatively restricted time period and thus represent a picture of bird distribution occurring in a given year, at a given season, and under a given set of environmental conditions. Whereas the relationship between the numbers actually occurring on the ground and those observed on the surveys may remain uncertain, we consider that aerial surveys are an excellent method of obtaining a picture of the relative distribution of birds over large areas, many of which may not be accessible from the ground, and thus of identifying areas of particular importance. The numbers observed will provide a minimum estimate of the totals in a given area, as not all birds are likely to be detected during the flights.

Many factors can affect observed distribution patterns over both shorter and longer periods of time. Short-term changes may result from disturbance, variations in food availability, or habitat conditions (e.g., movements in response to differing tide heights, flooding, weather patterns), seasonal changes may reflect seasonal shifts in food resources or the passage of migrants, and inter-year variations may result from large-scale shifts in habitat conditions (e.g., reflecting better or worse conditions at a remote site) or changes in population numbers reflecting differing breeding success. Considerable variation in numbers can result from carrying out surveys of the same area at different tide heights/conditions, although this was minimized in the present surveys by carrying out all surveys at moderately high to high tide heights. A few areas or sectors could not be covered owing to flight restrictions (e.g., the immediate area near the entrance to the Panama Canal) or weather, although areas not surveyed did not appear to contain prime shorebird habitat.

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# *Chapter 3*
# Geography, physical oceanography, and climate of Panama

F.S. Delgado

## 3.1 Introduction

Panama lies in the Neotropical Zone between approximately 7 and 10°N and 77 and 83°W (Map 3.1). It is situated at the junction of Central America and South America, forming a narrow, gently curved "S"-shaped isthmus oriented east–west between the two continents. At its northwestern end, it is bordered by Costa Rica and the rest of Central America, whereas its eastern end borders Colombia and the South American continent.

From the Colombian border, the country arches northwestward and then southwestward, with the southward extension of the Peninsula de Azuero forming the western margin of the Golfo de Panama on the Pacific side. In its western parts, the country tends northwestward again and becomes broader towards the border with Costa Rica. The isthmus is narrowest at the northern part of the Golfo de Panama, where only 80 km separate the coastal cities of Colon on the Caribbean Sea and Panama City on the Pacific Ocean. These two cities form the northern and southern termini, respectively, of the Panama Canal.

The mountains of the Cordillera Central form the backbone of the western part of the country, extending from Central America to the central regions of Panama. Two lower mountain ridges extend into the country from Colombia along the northern and southern coasts. There are extensive lowlands in the central and eastern areas, those towards the Panama/Colombian border being known historically as the "Darien gap."

The marine environments of the Caribbean Sea to the north and the Pacific Ocean to the south are very different. The Caribbean coast has few prominent geographical features. The eastern sectors are generally low-lying, with many coral platforms and hundreds of small offshore islands forming the Archipielago de San Blas. Sandy beaches backed by forested terrain are found along much of the central coastline. In the northwest, extensive mangrove complexes and low islands are scattered through the bays and lagoons of the Laguna de Chiriqui area in Bocas del Toro. The Pacific coast has a much larger diversity of coastal features, including large estuaries, gulfs, bays, low-lying mangrove complexes, and mountainous terrain. Several large islands are found off the Pacific coast, including the largest island in Central America, Isla de Coiba (493 km$^2$), west of the Peninsula de Azuero. Bird distribution on these islands is not considered in the present Atlas.

## 3.2 Geological and paleogeographical history

The geological history and paleogeography of the coastline of Panama are fairly well known (Recchi 1975; Gomez 1986). Central America was formed by the movement of a number of tectonic plates, including the Caribbean, Cocoa, Panama, and Nazcas blocks. The northwestern parts of the country are thought to have been formed in the Devonic–Carboniferous era some 350 million years ago, whereas the central and southern regions are dated mostly from the Cretaceous and Tertiary eras.

Three distinct geological areas (Caribbean, Central, and Pacific) emerged in Meridional Central America and determined the sinusoidal form of Panama (Dengo 1973). During the Cretaceous period, an oceanic abyssal fault existed in south-central Panama (Las Palmas–Azuero); volcanic islands, containing fossils of neritic habitats, appeared later. During the early Eocene, the region consisted mostly of shallow waters, before land finally emerged between the volcanic islands. Heavy marine sedimentation occurred in the western regions of Panama during the middle and upper Tertiary (Oligocene and Miocene), and geological activity in this area produced the hilly and highland areas of Chiriqui and Azuero (Gomez 1986). The rich fossil area of Gayllard is unique in that it represents the only known Miocene fauna in Central America, including a variety of molluscs and vertebrates. During this period, deep marine sedimentation occurred in the eastern regions of Panama, producing mostly radiolarian and foraminiferan fossils; this sedimentation stabilized in the Pliocene period.

Studies of foraminiferan distribution by Saito and Keigwin (in Gomez 1986) demonstrated that the separation of the Caribbean Sea and the Pacific Ocean by the Panamanian land mass occurred between 3.6 and 3.1 million years ago. The Panamanian land bridge connection not only facilitated the dispersal of flora and fauna between North and South America, but also isolated the marine faunas of the Caribbean Sea and the Pacific Ocean.

During the Quaternary period, an extensive marine regression occurred around the Panamanian isthmus, including the Chiriqui, Montijo, and Golfo de Panama regions. Present littoral morphology is correlated with the rise of sea level, which has resulted from the last glacial retreat (Recchi 1975) and which has continued until very recently (Cooke et al. 1985).

### 3.3 Climate and weather patterns

The climate of Panama is discussed in detail by IGNTG (1988) and Ridgely and Gwynne (1989).

Under the Köppen system, the overall Panamanian climate may be categorized as typically tropical. Regionally, the country has three tropical climate types: savanna (or monsoon), humid and wet, and humid and very wet. The diversity of climates in this relatively small geographical area results from the interaction of surface wind patterns, the position of the mountains, and the influence of the oceans on the Pacific and Caribbean slopes. The complex interactions of climate and geography have resulted in the recognition of 12 life zones in Panama (Tosi 1971).

Daily temperatures in Panama generally vary little between seasons and years (e.g., monthly averages for daily high temperatures range between 29 and 32°C over the year at Balboa), although they may be extreme in some arid regions (e.g., Divisa: 18.6–40.6°C). Likewise, temperatures may range from over 40°C at midday in the lowlands of the eastern side of the Peninsula de Azuero to 0°C during the night at the summit of Volcan Baru (3475 m). Temperatures on the Pacific slope are higher than on the Caribbean as a result of lower humidity and frequent clear skies. Temperatures are generally moderate along the coast and more extreme inland.

Annual precipitation varies widely in Panama. The lowest averages are recorded on the western side of the Golfo de Panama along the coastline of Bahia de Parita (Los Angeles Meteorological Station; 1018 mm), where only 90 rainy days occur per year. Precipitation tends to increase towards the interior and highlands, noticeably in western Chiriqui Province (Cuesta de Piedre Meteorological Station; 6172 mm), where more than 200 days of rain per year deluge the mountainous ridge of Panama (Contraloria General de la Republica 1986). The annual cycle of precipitation is determined by the northeasterly winds, known as "alisios" or "trade winds." These winds, which blow off the Caribbean Sea, have a high moisture content and result in heavy precipitation on the Caribbean coast and foothills, and they frequently produce low, hanging mist in the highlands. As a result, precipitation is heaviest on the Caribbean coast and highlands, and there is only a short dry season.

In contrast, there are well-defined dry and rainy seasons on the Pacific slope. Northeasterly winds become more intensive during the dry season, which lasts from early December to mid-March. During this period, cool winds build up during the day, so that by afternoon there may be a pleasant breeze. In the middle of February, the lowlands remain dry, and leaf-fall is very noticeable in the arid zone of central Panama. At the same time, the northeasterly trade winds increase the humidity and condensation on the Caribbean slope, resulting in frequent but short periods of rain. March and April are the hottest months; the weather at this time usually involves hazy and partly cloudy days with little or no wind.

On the Pacific slope, frequent rainfalls start in May and continue until October, when the Intertropical Convergence Zone (ITCZ) moves northward over Panama (see below). During this period, occasional tropical depressions, including hurricanes, may affect the Caribbean slope. In late November, the dry season has begun in earnest, and little or no rain falls on the Pacific slope until the following May.

During the rainy season, the typical daily weather pattern involves the formation of clouds by condensation during the early morning, the sky remaining cloudy through midday, a heavy shower in the mid- or late afternoon, and clearing during the night. In the lowlands, rainfall may be strong and heavy; storms are common but usually last no more than one or two hours. When the ITCZ is over Panama, cloudy conditions may last several days, with drizzle and showers combining to produce generally wet periods; local disturbances are also common, and flooding may eventually occur in various lowland areas of Panama.

### 3.4 Hydrological patterns

The mountains of the Central Ridge divide Panama into two major regions, with 70% of the land mass lying on the Pacific slope and the balance on the Caribbean side. As a result, rivers on the Pacific slope are generally longer (averaging 106 km with a mean gradient of 2.3%) than on the Caribbean side (average length and gradient 56 km and 2.5%, respectively). Lengths of the longest rivers on the Pacific and Caribbean slopes are compared in Table 3.1.

Some 164 watersheds have been defined for Panama. Runoff patterns are determined by geographical position, size and form of the landscape, and precipitation pattern, and they are very different on the Caribbean and Pacific slopes. On the Caribbean side, 20–30% of the annual runoff occurs during the dry season (January–April) and 70–80% during the rainy season (May–December). Seasonal differences are much more marked on the Pacific slope, with only 7–15% occurring during the dry season and 85–93% during the rainy season. Month-to-month variations in runoff are thus much less on the Caribbean side than on the Pacific, where runoff in the driest month is only 10% of that in the wettest month (IGNTG 1988). Highest monthly runoff occurs in June and October–November on the Caribbean slope and in October on the Pacific slope. Rivers located in the eastern part of the country (Darien and Panama provinces) have highest runoffs in November.

The average yearly surface runoff of all Panamanian rivers is 4570 $m^3/s$. The most important watersheds of Panama include the Changuinola, Indio, Cricamola, Calovebora, and Sixaola rivers on the Caribbean slope and the Chiriqui Viejo, Tabasara, and San Pablo rivers on the Pacific side, all of the latter being located in the western part of the country. All these rivers have a water production greater than 721 L/s per square kilometre. The Pacific slope has the highest level of water resources in Panama, although the lowest levels are found on the eastern side of the Peninsula de Azuero and in the lowlands of Cocle Province, with the exception of the Rio Santa Maria.

Watersheds of the Central Lowlands of the Pacific slope of Panama were altered dramatically as a result of colonization of the region by Spaniards in the 16th century. Slash-and-burn techniques led to extensive soil erosion and formation of deep troughs during the rainy season, as well as loss of fine soil particles throughout the area. This has particularly affected the salinity, pH, and volume of nutrients that are incorporated in the ocean annually. This effect has continued and increased year by year, with the development of new land for agriculture and cattle-raising in other regions of the Pacific and, two decades ago, on the Caribbean slope.

**Table 3.1**
Lengths of rivers on the Pacific and Caribbean coasts of Panama

| Pacific coast | | Caribbean coast | |
|---|---|---|---|
| Rio Bayano | 280 km | Rio Chagres | 125 km |
| Rio Chucunaque | 232 km | Rio Changuinola | 118 km |
| Rio Tuira | 230 km | Rio Indio | 97 km |
| Rio Santa Maria | 173 km | Rio Chionmola | 83 km |
| Rio Balsas | 152 km | | |
| Rio Chiriqui Viejo | 125 km | | |
| Rio La Villa | 110 km | | |

## 3.5 Oceanographic characteristics

### 3.5.1 Physiography

The Panamanian isthmus is located between the Clarke depression in the Caribbean Sea and the Panamanian depression in the Pacific Ocean; the latter is part of the Cocoa–Nazcas tectonic plate, which is more than 400 m deep.

The Caribbean coastline is some 1290 km long, and the Pacific coast approximately 1700 km. On the Caribbean side, the continental platform is narrow (5.8–39 km) and includes some 600 km$^2$ of rocky and coral substrates. In contrast, the Pacific continental platform is much wider and covers approximately 19 000 km$^2$. It may be subdivided in three regions: Coiba (3474 km$^2$), Azuero (644 km$^2$), and the Golfo de Panama (12 880 km$^2$).

The Caribbean coastline has two prominent marine complexes. The Bocas del Toro region is located in the west and consists of a closed gulf, the Laguna de Chiriqui, which contains a number of medium-sized islands of ancient origin: Colon (61 km$^2$), Popa (53 km$^2$), Sastimentou (51 km$^2$), Cristobal (37 km$^2$), and Cayo de Agua (14 km$^2$). This area has a wide continental platform and shallow, clear waters (see below). The second major marine complex lies along the eastern part of the coast: it is known as the Archipielago Las Mulatas, or the "Kuna Islands." The area includes more than 360 small islands and rockeries extending towards the Colombian border, all of which are coral in origin. The central region of the Caribbean shoreline, the Golfo de los Mosquitos, has a narrow continental platform with only one island, Escudo de Veraguas (3.5 km$^2$). The remainder of the coastline lying east of the Panama Canal consists of a rocky coastline strewn with coral platforms.

Coiba is the most westerly of the three major regions of the Pacific continental platform. It contains a number of volcanic islands at its eastern end, including the largest island in the eastern Pacific, the Isla de Coiba (493 km$^2$), as well as Jicaron (20 km$^2$), Paridas, Contreras, and Secas. The region includes the Golfo de Chiriqui, in which a number of estuarine islands are located, of which the largest is the Boca Brava (28 km$^2$).

The narrowest part of the continental platform is found in the Azuero region, where it is no wider than 3 km along the south coast of the Peninsula de Azuero. There are a few islands in the Golfo de Montijo lying to the west of the Peninsula de Azuero, including Cebaco (80 km$^2$), Leones (14 km$^2$), Gobernadora, and Tigre.

The Golfo de Panama is the largest and most important of the marine areas, measuring some 150 km north to south and 245 km east to west. Offshore, in the east-central part of the gulf, lies the Archipielago de Las Perlas, which includes a number of quite large islands, including Rey (234 km$^2$), San Jose (44 km$^2$), and Pedro Gonzalez (14 km$^2$). Smaller coastal islands are found towards the southern part of the Peninsula de Azuero, including Taboga, Taboguilla, Uraba, Otoque, Taborcilla, and Iguana. The region contains the most extensive areas of intertidal habitats found in Panama. These are located in four major sections of coastline, including the Bahia de Parita in the west, the Bahia de Chame in the northwest, the Bahia de Panama in the most northerly, central part of the gulf, and the Golfo de San Miguel in the Darien region at the eastern border of the Golfo de Panama. These areas all have extensive stands of mangroves along their shorelines and wide intertidal mud- and sandflats. Large areas of muddy substrates and salt pans are found behind the outer shoreline in the Bahia de Parita.

The continental platform extends across the entire Golfo de Panama. The subsea topography slopes gradually from north to south, with a submarine valley starting near the Rio Bayano at a depth of 40 m and deepening southwestward towards the edge of the continental platform. The boundary of the continental platform runs across the mouth of the Golfo de Panama some 10 km offshore from the eastern and western extremities of the gulf, with ocean depths dropping from 200 to 3000 m in the open sea (Defense Cartography Agency 1982).

### 3.5.2 Marine currents and tides

Climate is highly influential in determining the oceanographic patterns found on both the Caribbean and Pacific coasts of Panama. Seasonal variation in patterns is associated with cyclical movements of the ITCZ. From May to November, the northerly trade winds ("alisios") decrease in intensity and the ITCZ moves into the Northern Hemisphere, where it is located over Panama and Central America, especially in October. During this period, rainfall is frequent and intense (Forsberg 1969). From December to April, the trade winds become more intense and the ITCZ moves southward away from Panama, resulting in a dry season (see above).

Marine currents circulate eastward in the Caribbean Sea and westward in the Pacific Ocean and are influenced by tidal patterns. Tides in the Caribbean Sea are diurnal, with a range of generally less than 1 m, although this may be greatly influenced by weather. Tidal ranges on the Pacific coast are considerably larger and are influenced by geographical location on the isthmus, phase of the moon, local shoreline topography, and weather. Amplitudes of spring tides reach 5.75 m during the year and usually have two peaks, during the dry season and late rainy season.

Marine currents in Bahia de Parita average 385 m/h with a nautical direction of 340° during the incoming tide and 341 m/h with a nautical direction of 160° during the falling tide. This results in a net flooding tide with a direction of south-southwest (Almendas et al. 1993). The principal oceanic current on the Pacific coast of Panama is the Humboldt (Peruvian) Current, which flows east to west and is regulated by the ITCZ.

### 3.5.3 Seasonal upwelling

Seasonal upwelling effects that occur in Panamanian coastal waters have been well documented by a number of authors (Flemming 1939; Schaefer et al. 1958; Forsberg 1963, 1969; Smayda 1966; Glynn 1972, 1977; D'Croz and Winter 1980; Kwiecinski and Chial 1983; D'Croz et al. 1991), and the information presented here represents a general overview of the topic. A comparison of major climatic

and oceanographic conditions in the Golfo de Panama and Golfo de Chiriqui is presented in Table 3.2 (from Kwiecinski and Chial 1983).

3.5.3.1 Winds

As mentioned above, upwelling off the coast of Panama is caused by the northeasterly trade wind system, but the main geographical features of Panama result in two rather distinct oceanographic regions with regard to upwelling, namely the Golfo de Panama and the waters west of the Peninsula de Azuero. When the trade winds (north-northeasterly) are positioned over Panama during the dry season starting in December, the high mountains in the west of the country impede wind movement across the Panamanian isthmus and restrict the influence of the wind on the coastal waters off the western part of the country. The lower terrain in the central parts of the country presents less of a barrier to the winds. Thus, during the dry season, wind velocities over the Golfo de Chiriqui average 20 km/h compared with 42 km/h over the Golfo de Panama (Smayda 1966; Kwiecinski and Chial 1983). Winds over the Golfo de Panama are intensive enough to produce offshore movement of surface water, resulting in upwelling of colder, nutrient-rich waters. Winds are not strong enough to produce this effect in the west, and the coastal zone between the Peninsula de Azuero north to the Golfo de Papagayo, Costa Rica, comprises the southernmost sector of the warmest and thermally most stable water mass in the eastern Pacific (Renner 1963; Glynn 1977).

3.5.3.2 Temperature

Surveys have shown that sea surface temperatures during the dry season are some 5°C lower in the Golfo de Panama (23.35°C), as a result of the upwelling of cool water, than in the Golfo de Chiriqui (29.19°C). During the rainy season, temperatures in the two gulfs are more constant, with somewhat higher temperatures occurring in the Golfo de Panama (averaging about 3.4°C higher); the cooling effect from rain and somewhat higher surface runoff from small streams entering the Golfo de Chiriqui are probably responsible for this reversal in pattern (Glynn 1977).

3.5.3.3 Salinity

Seasonal patterns of salinity appear to be similar in the Golfo de Panama and Golfo de Chiriqui, with possibly slightly, but not significantly, lower seasonal differences in the Golfo de Chiriqui. Dry season salinities are usually in the range 32–35 ppt, whereas rainy season salinities are generally below 30 ppt; lowest values (25–28 ppt) occur most frequently between September and November, when rainfall is more intense (Dana 1975).

3.5.3.4 Cloud cover and light levels

Seasonal patterns of cloud cover are similar in the two gulfs, with median cover of about 20% from December through April/May. From May/June to the end of November, overcast conditions prevail. Light levels at a depth of 3–5 m are higher in the Golfo de Chiriqui than in the Golfo de Panama in both rainy and dry seasons (Glynn 1977).

3.5.3.5 Phosphate concentration

Phosphate levels vary with depth, decreasing from some 34 mg-at/m$^2$ to 55 mg-at/m$^2$ between 20 and 40 m during the rainy season (Smayda 1966). Kwiecinski and Chial (1983) reported that peak concentrations of phosphate in the Golfo de Panama built up between November (30 mg-at/m$^2$) and March (77 mg-at/m$^2$); concentrations in the Golfo de Chiriqui at the same times were considerably lower (12 and 17 mg-at/m$^2$, respectively). The flow limit on the photic level in the Golfo de Panama during the dry season is 11 m (0.5 mg-at $PO_4$/L), compared with 27 m (0.3 mg-at $PO_4$/L) in the Golfo de Chiriqui; consequently, photosynthetic activity and biomass are higher in the Golfo de Panama than in the Golfo de Chiriqui.

3.5.3.6 Phytoplankton

Most phytoplankton found in the Golfo de Panama are thought to be native, or resident, as species occurring during rainy and dry seasons are almost similar. During the dry season (December–April), phytoplankton (mostly diatoms) increase in abundance in nearshore waters affected by upwelling. Dinoflagellates also increase during the dry season. Blooms of dinoflagellates have also been observed at the beginning of the rainy season, possibly in response to the marked environmental changes taking place between seasons (D'Croz et al. 1991).

Smayda (1966) reported a very stable seasonal succession of phytoplankton in the Golfo de Panama. It was possible to relate effects of upwelling on the phytoplankton in a direct and immediate way, in that a decline in sea temperatures and an increase in dissolved nutrients were followed by high abundances of chlorophyll a and phytoplankton.

### 3.5.4 Effects of upwelling on coastal and marine biota

Long-term surveys of coral growth in upwelling and non-upwelling areas of the Pacific coast of Panama have demonstrated that coral development declines markedly during the dry season, when upwelling occurs and sea temperatures are lower; it also decreases gradually with increasing cloud cover during the rainy season (Glynn 1977). Water temperatures were significantly correlated with coral growth in upwelling areas of the Golfo de Panama. Evidence that sea temperatures significantly influenced coral development included observations that northern and eastern sides of islands, where there is protection from upwelling currents and thus higher sea temperatures, were preferred sites for coral growth and reef development (Glynn and Stewart 1978). On the west side of Isla Saboga, for instance, coral growth nearly ceased during upwelling, when temperatures were lowest, despite water transparency being generally at its highest level.

Seasonal upwelling also has a remarkable influence on marine organisms in the Golfo de Panama, including medusas, molluscs, and crustaceans. Upwelling is associated with increased activities of nectonic organisms; medusas (coelenterates, mostly *Aurelia*), for instance, are more abundant in nearshore waters and are more often reported in accidental incidents with bathers during this upwelling period.

The Golfo de Panama supports more than 250 species of molluscs, of which 67 are endemic to Panamanian waters (Dieguez de Ho 1986). A number of species of molluscs reproduce during the period of upwelling in the gulf.

**Table 3.2**
Climatic and oceanographic data in the Golfo de Panama and Golfo de Chiriqui (from Kwiecinski and Chial 1983)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | | | | | | | | | | | | |
| Golfo de Panama | 27 | 15 | 15 | 76 | 198 | 198 | 185 | 196 | 191 | 250 | 251 | 137 |
| Golfo de Chiriqui | 29 | 16 | 47 | 107 | 296 | 313 | 273 | 317 | 423 | 400 | 314 | 63 |
| Northerly wind force index | | | | | | | | | | | | |
| Golfo de Panama | 29.5 | 41.0 | 43.5 | 24.1 | 8.9 | 3.7 | 9.1 | 8.2 | 3.5 | 2.4 | 6.9 | 14.3 |
| Golfo de Chiriqui | 11.6 | 19.2 | 18.3 | 0.5 | 1.5 | 0.5 | 0.5 | 0.7 | 0.6 | 0.4 | 0.5 | 2.0 |
| Sea surface temperature (°C) | | | | | | | | | | | | |
| Golfo de Panama | 26.3 | 24.9 | 23.7 | 25.6 | 27.8 | 28.3 | 28.1 | 28.0 | 28.3 | 28.0 | 28.4 | 27.3 |
| Golfo de Chiriqui | 29.6 | – | 30.0 | 30.0 | 29.9 | – | – | 29.4 | 27.5 | 28.6 | 27.9 | 27.9 |
| Sea surface salinity (ppt) | | | | | | | | | | | | |
| Golfo de Panama | 31.4 | 33.2 | 34.5 | 34.3 | 33.0 | 30.2 | 29.9 | 30.0 | 28.5 | 27.4 | 27.4 | 28.8 |
| Golfo de Chiriqui | 30.0 | – | 32.4 | 33.3 | 33.0 | – | – | 30.6 | 30.3 | 30.3 | 29.9 | 29.4 |
| Coefficient of extinction | | | | | | | | | | | | |
| Golfo de Panama | 0.17 | 0.28 | 0.21 | 0.15 | 0.08 | 0.19 | 0.17 | 0.15 | 0.11 | 0.10 | 0.24 | 0.15 |
| Golfo de Chiriqui | 0.06 | – | 0.09 | 0.11 | 0.13 | – | – | 0.13 | 0.21 | 0.12 | 0.10 | 0.07 |
| Depth (m) 10% incident radiation | | | | | | | | | | | | |
| Golfo de Panama | 13 | 8 | 10 | 14 | 24 | 11 | 13 | 14 | 19 | 21 | 9 | 14 |
| Golfo de Chiriqui | 37 | – | 23 | 20 | 16 | – | – | 16 | 10 | 17 | 21 | 30 |
| Phosphates ($PO_4$-P µg-at/L) at 20 m depth | | | | | | | | | | | | |
| Golfo de Panama | 1.88 | 1.27 | 2.07 | 1.07 | 1.01 | 0.84 | 0.86 | 0.75 | 0.64 | 0.47 | 0.66 | 0.87 |
| Golfo de Chiriqui | 0.3 | – | 0.3 | – | 0.35 | – | – | 0.3 | – | 0.3 | 0.3 | 0.3 |
| Phosphates ($PO_4$-P µg-at/L) at 40 m depth | | | | | | | | | | | | |
| Golfo de Panama | 2.52 | 2.26 | 3.06 | 2.06 | 1.94 | 1.49 | 2.18 | 1.87 | 1.46 | 1.46 | 1.51 | 1.94 |
| Golfo de Chiriqui | 0.3 | – | 1.1 | – | 0.55 | – | – | 0.5 | – | 0.3 | 0.3 | 0.3 |

The main periods of reproduction of many species of crustaceans, including shrimp populations of commercial importance, are associated with the upwelling that occurs during the dry season (D'Croz 1985). During upwelling, species such as *Penaeus*, *Xyphopenaeus*, and *Trachypenaeus* invade the mangrove ecosystems to lay their eggs. Because of this, the Marine Resources Department of the Panamanian government has suspended commercial capture of shrimps in February and March each year. Millions of juvenile shrimps move by reotaxia up the principal rivers of the central provinces of Panama, beginning in November. During this period, traditional fishermen use manual nets to capture the numerous "titi" (a traditional name for the juvenile shrimp), after which the shrimp are sun-dried, preserved, and used for making soups and scrambled eggs. The migration period extends for no more than two weeks at the end of the rainy season.

Surveys have shown that the regional distribution of the False Anchoveta *Cetengraulis mysticetus*, which is the most abundant sardine in the Golfo de Panama, changes in response to the upwelling. During the rainy season, juvenile anchovetas live in deep marine waters. In April, they move closer to the coastline and are found along areas with muddy substrates and depths of less than 10 m (Bayliff 1966). The largest catches of anchovetas occur in the northern Golfo de Panama, where extensive estuarine systems and mangrove forests are found between the provinces of Chame and Darien. Adult anchovetas feed on detritus and very small benthic organisms, mixing up the muddy substrate. D'Croz (1985) reported egg laying by anchovetas in the inshore waters near Panama Viejo and Juan Diaz mangrove forests and suggested that a correlation existed between the abundant detritus found in mangroves and the presence of this marine sardine.

A number of other typical marine fishes, such as jacks, snappers, and bass, are also more active during the period of upwelling and form a prominent component of the commercial fishery in the northern Golfo de Panama.

The migration of shrimps and small freshwater fishes up the central rivers of Panama at the end of the rainy season increases the activity of estuarine fishes such as groupers *Micropogon*, snooks *Centropomus*, grunts *Pomadasys*, and snappers *Lutjanus*. This occurs before the massive migration during the two-week period when the river waters are more transparent a few weeks before the intensive upwelling. It is a tradition in the central provinces of Panama, in fact, that local fishermen make false streams on the large rivers to catch small shrimps and fish — this is an annual activity, for example, on the largest river of the central region of Panama, the Rio Santa Maria.

The upwelling also has a remarkable influence on the trophic processes occurring in estuaries and mangrove forests. The upwelling effects of the trade winds not only increase the activity of phytoplankton (see above), but also result in increases in small marine and intertidal organisms such as polychaetes, molluscs, and microcrustaceans. This situation is likely to benefit migratory populations of shorebirds and waterbirds. Although many are present during migration periods in October before major upwelling occurs, upwelling is likely to benefit those that remain for the wintering period, which includes the start of the upwelling in December and January, as well as migration periods later in the spring. It would appear that wintering populations of shorebirds are likely to benefit from more readily available food resources that will occur in profitable habitats in estuaries, bays, and large mangrove forests as a result of the upwelling. Upwelling is less likely to influence waterbirds nesting on inland habitats and more likely to affect resident herons on offshore islands, where the nesting period occurs during the dry season, when upwelling is in progress (see Wetmore 1965).

Surveys of marine and coastal birds in the Golfo de Panama have been carried out by various researchers (Wetmore 1965; Ridgely 1976; Engelman 1983; Montgomery and Martinez 1984; N.G. Smith, unpubl. data, cited in Ainley et al. 1988; Loftin 1991). Upwelling appears to be important in the life cycles of these birds. Peak nesting periods of various species of seabirds on small islands of the Archipielago de Las Perlas occur in February/March, when sardines, a basic

food resource for seabirds, are abundant because of the upwelling. Few nesting colonies were detected during the rainy season, especially in the western portion of the Golfo de Panama (Isla Iguana, and also the Islas Secas, Golfo de Chiriqui). This phenomenon may be associated with local climatic or ecological conditions yet to be determined. The El Niño – Southern Oscillation (ENSO) also has a marked negative influence on breeding colonies of seabirds in the Golfo de Panama (see below).

### 3.5.5 The El Niño – Southern Oscillation (ENSO)

Much study has been devoted to the ENSO phenomenon, which involves the incursion of warm water off the coast of southern Ecuador and northern Peru. When the El Niño event is particularly strong, its influence may extend over much of the tropical and subtropical regions of the eastern Pacific. The most obvious effects of El Niño in the eastern Pacific include anomalous sea surface warming; reduction of the upwelling, or upwelling of nutrient-poor waters; a marked decline in primary productivity and fisheries stocks; intensified storms with higher sea levels; and high rainfall with frequent flooding (Glynn 1990).

El Niño events lead to spectacular biological consequences. The 1982–83 El Niño was probably the strongest marine warming event to occur this century and affected a wide region of the globe. The marked deepening of the thermocline and resulting trophic impoverishment of the surface water negatively affected algal productivity. This depletion of the basic plant food resource resulted in significant reduction in stocks of zooplankton, bait fish, and squid (Glynn 1990), which led to mass migration and near total reproductive failure of marine birds — in February 1983, for instance, up to 7000 Peruvian Boobies *Sula variegata* and 10 000 Blue-footed Boobies *S. nebouxii* appeared unexpectedly in the Bahia de Panama (Aid et al. 1985). It appeared that reproductive cycles may have been sharply interrupted just prior to laying because of food shortages, causing the birds to leave their breeding areas. In subsequent months, populations in the Golfo de Panama decreased rapidly, up to 50%, and by June 1984 no Peruvian Boobies and only 75 Blue-footed Boobies remained in the Golfo de Panama. High mortality of birds appeared to occur, and few boobies were detected returning to their breeding grounds (Ainley et al. 1986). Many of the pelagic birds and seabirds invading the Golfo de Panama during the El Niño event of 1982–83 came from the Galapagos Islands and the western region of the Pacific Ocean (Engelman 1983). In Panama, waterbirds also suffered from the drought that noticeably affected the central regions of Panama, depleting food resources in rivers, swamps, lagoons, mangroves, and mudflats. Glynn (1990) summarized the situation as follows: "ENSO events dramatically show the atmosphere, ocean and land links, and how small changes in surface temperatures can alter global climate patterns affecting a vast array of the world's biota. This recent global disturbance underlines the intricate physical and biotic connections in the biosphere and the fragility of many tropical ecosystems to climatic disturbances."

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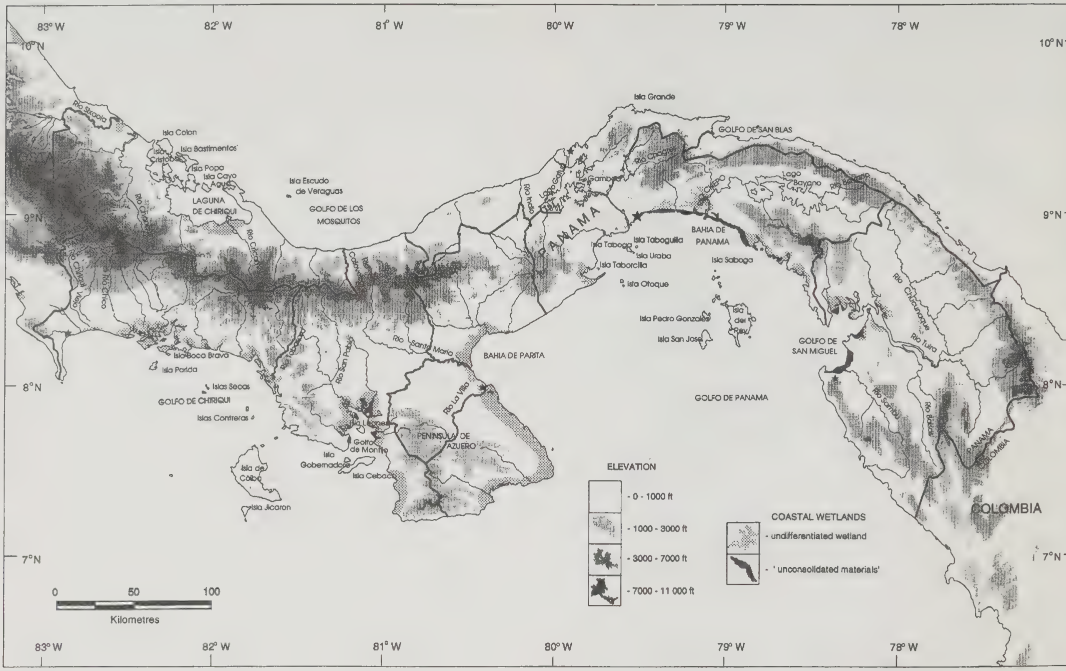
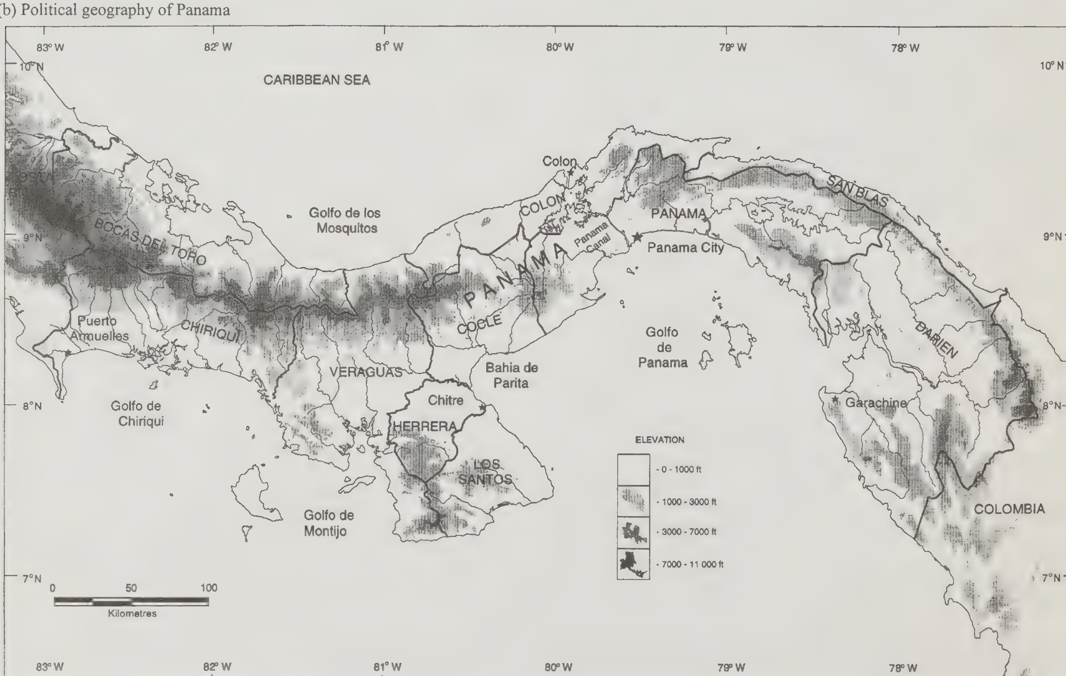
**Map 3.1**
(a) Physical geography of Panama




(b) Political geography of Panama



# *Chapter 4*
# Coastal habitats and their distribution in Panama

R.I.G. Morrison and R.K. Ross

## 4.1 Introduction

The distribution and extent of coastal habitats will play a major role in determining the distribution and abundance of shorebirds and other groups of birds on the coast of Panama. The underlying geology and geomorphology, in combination with oceanographic and other environmental factors and conditions (see Chapter 3), will determine the types and amounts of habitats that form in different areas and whether the habitats are productive and able to provide abundant food resources for the different groups of birds. A variety of coastal habitats of greater or lesser suitability for shorebirds and other birds is found in Panama, including mudflats, sandflats, sandy ocean beaches, mangrove-lined inlets, rocky shores, broad coral platforms, and developed urban shorelines. This chapter provides a basic, descriptive account of the major habitat types found around the coast of Panama. Descriptions are based on the aerial survey sectors and proceed in a clockwise fashion around the country, starting in the northwest: from west to east along the Caribbean coast, and from east to west along the Pacific coast. The major intertidal and shoreline habitats occurring in each sector (see Chapter 2, Methods) are described in Table 4.1 and illustrated in Maps 4.1–4.8. In the following text, survey sectors are grouped into "ecozones," in which similar types of habitats in a group of sectors form an ecologically relatively homogeneous stretch of coast.

## 4.2 Caribbean coast (Sectors 1–50) *(Maps 4.1–4.4)*

The Caribbean coast consists of several distinct regions. (1) In the northwest, the islands of the Archipielago de Bocas del Toro, enclosing Bahia Almirante and the Laguna de Chiriqui, contain many areas of low mangrove; however, with the low tidal ranges that are found on this coastline, there appears to be very little development of intertidal habitats, and in most areas vegetation grows close to the edge of the water. (2) Long stretches of beaches, both sand and gravel, mixed with low rocky points, stretch from the Peninsula Valiente on the east side of the Laguna de Chiriqui to near the port of Colon at the northern terminus of the Panama Canal. (3) From east of Colon to El Porvenir, coral platforms become a prominent feature of the shoreline, backed by a combination of sandy beaches, low mangroves, rocky points, and a forested coastal plain or hills. (4) From El Porvenir to the border with Colombia, the coastline of San Blas consists mostly of sandy beaches, coral platforms, and stretches of low mangrove, backed by palm forests and other types of tropical forest. The low islands of the Archipielago de San Blas are strung along the coast offshore.

### 4.2.1 Changuinola/Bocas del Toro outer coastline (Sectors 1–6) *(Map 4.1)*

The mainland coast from the Costa Rica/Panama border to the Bocas de Drago (Sectors 1 and 2) consists mostly of straight, grey, wave-washed sand beach backed by palm forest. The lagoon at the mouth of the Rio San San is found behind the shoreline in Sector 1, although there appears to be little muddy habitat around its edges. South of the Rio Changuinola (Sector 2), the grey sand beach is backed by a mixture of open grassy areas and palm forest.

The outer shoreline of the first two islands of the Archipielago de Bocas del Toro, Isla Colon and Isla Bastimentos (Sectors 3 and 4, respectively), consists of mixtures of yellow or orange sandy beaches interspersed with either low, rocky points covered with forest or coral platforms. The shoreline is backed by a mixture of forest, open forest, and, in some cases, open scrubby terrain or cleared land. Similar habitats occur along the southeastern side of Isla Bastimentos (Sector 5) and on the Caribbean side of Isla Popa (Sector 6), and fringes of low mangrove forest are found along the more sheltered parts of these coasts.

### 4.2.2 Islands of the Archipielago de Bocas del Toro/ Bahia Almirante (Sectors 7–13) *(Map 4.1)*

The coast of Cayo Agua (Sector 7) is generally rockier and steeper than the preceding sectors, as are the coasts of Isla Popa facing the Laguna de Chiriqui (Sector 8), and there appears to be little or no intertidal habitat.

The interior shorelines of Isla Popa (Photo 1), Isla Bastimentos (Sector 9), and Isla Colon (Sector 10), which enclose Bahia Almirante, are generally low-lying, as are the many small offshore islands that dot the bay. Most of the shoreline and offshore islands are covered by low, flooded, scrubby mangrove, and there appears to be little muddy or other intertidal substrate available.

Most of the interior shoreline of Bahia Almirante (Sectors 11–13) is lined with mangrove stands backed by forest. There appears to be little development of intertidal habitats, and water floods well into the mangroves in most areas. In the eastern part (Sector 11), the terrain is generally flat,

**Table 4.1**
Major habitats occurring in survey sectors on the coast of Panama

| Sector | Location | Habitat description |
|---|---|---|
| **Caribbean coast** | | |
| 1 | Changuinola: outer coast | sandy beach / palm forest, lagoon |
| 2 | Changuinola: outer coast | sandy beach / palm forest, open grassy area |
| 3 | Archipielago de Bocas del Toro: outer coastline | sand beaches, some coral reef / palm forest with open areas |
| 4 | Archipielago de Bocas del Toro: outer coastline | sand beach with some coral platforms / forest |
| 5 | Archipielago de Bocas del Toro: outer coastline | sand beach, some mangroves fringing shore / forest |
| 6 | Archipielago de Bocas del Toro: outer coastline | sand beach, mangrove fringes / forest |
| 7 | Archipielago de Bocas del Toro: outer coastline | rocky cliffs, some sand beach / forest and grassy hills |
| 8 | Laguna de Chiriqui: north shore | mangroves / forested hills |
| 9 | Archipielago de Bocas del Toro: Bahia Almirante | scrubby mangrove (no muddy substrate) / forest |
| 10 | Archipielago de Bocas del Toro: Bahia Almirante | scrubby mangrove / forest |
| 11 | Archipielago de Bocas del Toro: Bahia Almirante | tall mangroves / palms and forest, some swampy areas |
| 12 | Archipielago de Bocas del Toro: Bahia Almirante | mangroves / forested hills, some muddy interior |
| 13 | Archipielago de Bocas del Toro: Bahia Almirante | low mangrove / forested or grassy hills |
| 14 | Laguna de Chiriqui: west shore | low mangrove / forest |
| 15 | Laguna de Chiriqui: south shore | low mangrove, with some sandy areas / forest and some hills |
| 16 | Laguna de Chiriqui: Punta Cricamola | low sandy beach / flat land with forest and some mangroves |
| 17 | Laguna de Chiriqui: east shore | low mangrove, with some sandy beaches / forest, some hills |
| 18 | Peninsula Valiente: ocean shore | rocky points with sandy beaches, some coral / forest |
| 19 | Laguna de Chiriqui: south shore | sand beaches, some mangroves / low vegetated points, hills and forest |
| 20 | Golfo de los Mosquitos: Rio Chiriqui | sand beach / flat forested hinterland |
| 21 | Golfo de los Mosquitos: south shore | gravel and sand beach with rocky points / forested hills |
| 22 | Golfo de los Mosquitos: Calovebora | sandy beaches in coves between rocky points / forested hills |
| 23 | Golfo de los Mosquitos: Veraguas | sandy beaches in coves between rocky points / forested hills |
| 24 | Golfo de los Mosquitos: east shore | — not surveyed — habitats same as Sectors 22 and 23 |
| 25 | Punta Limon | sandy stretches, low rocky platforms / forest |
| 26 | Punta Masueto | sand beaches and small cliffs / forest and palms |
| 27 | Palmas Bellas | sandy beaches and low rocky points / flat hinterland, forest and plantations |
| 28 | Colon | rocky platform and points, some sandy areas / urban areas |
| 29 | Puerto Pilon | mangroves and coral platforms / hills |
| 30 | Portobelo | coral platforms and some mangroves / forested hills |
| 31 | Cacique/Isla Grande | coral platforms and some mangroves / steep hills and forest |
| 32 | Nombre de Dios | coral platforms and some mangroves / steep hills |
| 33 | Punta Rincon | coral platforms and sandy beaches / flat forested hinterland |
| 34 | El Porvenir | coral platforms and sandy beaches / low mangrove inlets, forested terrain |
| 35 | Mandinga | low mangroves and sandy beaches / heavy palm forest, some low hills |
| 36 | Carti | low mangroves and sandy beaches / heavy palm forest, some low hills |
| 37 | Archipielago de San Blas | low mangroves, some sandy beaches / flat palm forest |
| 38 | Isla Tigre | sand beach, some coral platform / flat palm forest |
| 39 | Playon Grande | sand beaches, some coral platforms and mangroves / palm forest backed by hills |
| 40 | Playon Grande/Playon Chico | sand beaches, some coral platforms and mangroves / palm forest backed by hills |
| 41 | San Ignacio de Tupile | sandy beaches / palm forest |
| 42 | Wannukani to Ailigandi | sandy beaches with some coral platforms and mangrove / palm forest |
| 43 | Ailigandi to Ustupo | sandy beaches with some coral platforms and mangrove / palm forest |
| 44 | Bahia de Masargandi | sandy beaches, some mudflats in bays lined with mangroves, some coral platforms / palm forests |
| 45 | Punta Mosquito to Isla Pino | coral platforms with sandy beaches / flat palm forest |
| 46 | Isla Pino/Caledonia | coral platforms with sandy beaches, occasional mangrove / flat palm forest |
| 47 | Caledonia to Punta Escoces | coral platforms with sandy beaches, occasional mangrove / forest and hills |
| 48 | Punta Escoces to Punta Cainundi | rocky steep shoreline with sandy or gravelly coves / forested hills |
| 49 | Punta Cainundi to Puerto Obaldia | long sand and gravel beach / forested hills |
| 50 | Puerto Obaldia to Cabo Tiburon | — not surveyed — steep rocky shoreline, forested hills |
| **Pacific coast** | | |
| 51 | Colombian border to south of Jacque | — not surveyed — steep rocky forested coastline |
| 52 | Jacque | muddy inlet, sandy beach, bays with steep rocky headlines / mountain slopes with forest |
| 53 | Punta Pina to Punta Caracoles | steep rocky shoreline, occasional sandy beach / mountain slopes with forest |
| 54 | Punta Caracoles to Punta Garachine | steep rocky shoreline, occasional sandy beach / mountain slopes with forest |
| 55 | Golfo de San Miguel: Ensenada de Garachine | mudflats backed by mangrove, occasional sandy beach / low forest and hills |
| 56 | Golfo de San Miguel: Punta Patino to Punta Morro de Buena Vista | mangroves, some mudflats along forested shoreline, interspersed with rocky points / low forest and hills |

*Continued*

**Table 4.1** *(cont'd)*
Major habitats occurring in survey sectors on the coast of Panama

| Sector | Location | Habitat description |
|---|---|---|
| 57 | Golfo de San Miguel: Punta Morro de Buena Vista to Punta San Lorenzo | mangrove shoreline, some mudflats / low forested flat hinterland |
| 58 | Punta San Lorenzo to Punta Bruja | rocky shoreline with some sandy beaches / steep forested hills |
| 59 | Punta Bruja to Isla Majaguel | sand and muddy flats, some sand beaches, low mangroves / forest |
| 60 | Isla Majaguel to Rio la Maestra (W) | muddy flats, sand beaches and mangroves / forested hinterland |
| 61 | Rio la Maestra to Isla Chepilo | broad mudflats, sand beach, mangroves / low forest |
| 62 | Isla Chepilo to Panama City (E) | broad mudflats, sand beach, mangroves / low forest and agricultural land |
| 63 | Panama City | Panama City: rocky and muddy foreshore / city |
| 64 | Panama City (Vacamonte to Punta San Juanito) | sandy flats, some beaches / agricultural land, hills |
| 65 | Bahia de Chame | estuarine bay with mudflats and mangroves, sandy beaches lining enclosing point / low mangrove, open scrubby areas |
| 66 | Punta Chame to Punta Prieta | long sandy beach / scrub and forest, shrimp ponds, low point and hills |
| 67 | Punta Prieta to Rio las Guias | sand beach with sandstone cliffs / scrubby forest |
| 68 | Rio las Guias to Quebrada Cienaga Larga | sand beach / scrub and agricultural land |
| 69 | Bahia de Parita (N): Quebrada Cienaga Larga/Punta de Piedra | sandspits enclosing muddy inlets with mangroves at north; mudflats, mangroves, open salt pans and shrimp ponds behind shore / agricultural land and scrub forest |
| 70 | Bahia de Parita (S): Punta de Piedra to Chitre Point | mudflats, mangroves, open salt pans and shrimp ponds behind shore / agricultural land and scrub forest |
| 71 | Peninsula de Azuero (E): Chitre Point to Quebrada la Honda | sand beach / scrub, forest and agricultural land |
| 72 | Peninsula de Azuero (E): Quebrada la Honda to Rio Mensabe | sand beach / scrub, forest and agricultural land |
| 73 | Peninsula de Azuero (E): Rio Mensabe to Rio Purio | sand beach / scrub, forest and agricultural land |
| 74 | Peninsula de Azuero (E): Rio Purio to Punta Mala | sand beach and dunes / scrub, forest and agricultural land |
| 75 | Peninsula de Azuero (S): Punta Mala to Rio Orio | sand and gravel beach with rocky points / hills, grazing land |
| 76 | Peninsula de Azuero (S): Rio Orio to Rio de Cana | steep rocky coastline with some sandy bays / steep hills |
| 77 | Peninsula de Azuero (S): Isla de Canas estuary | sandy bar enclosing mangrove estuary / agricultural land and grassy hills |
| 78 | Peninsula de Azuero (S): Punta Guanico to Punta Morro de Puercas | sandy beach, some steep rocky sections / hills and agricultural land |
| 79 | Peninsula de Azuero (S): Punta Morro de Puercas to Punta Blanca | steep rocky hillsides, some beaches / hills with grassy and forested slopes |
| 80 | Peninsula de Azuero (S): Punta Blanca to Punta Mariata | steep rocky shore, some sand and gravel beaches / grassy and forested hills |
| 81 | Peninsula de Azuero (W): Punta Mariata to Boca Vieja | steep rocky shore, some sand and gravel beaches / grassy hills |
| 82 | Peninsula de Azuero (W): Boca Vieja to Punta Duarte | sand beaches and rocky points, some mangrove-lined inlets / flat valley floor with forest and fields, some hills |
| 83 | Golfo de Montijo: Punta Duarte to Punta Corotu | rocky promontories with sandy bays / eroded "badland" hills in south |
| 84 | Golfo de Montijo: Punta Corotu to Isla Verde | low mangrove-lined shore, some (mud)flats / low forest and hills |
| 85 | Golfo de Montijo: Isla Verde to Isla de Papagaya | tall mangrove-lined shore, some (mud)flats / forests |
| 86 | Golfo de Montijo: Isla de Papagaya to Punta Camaron | low mangrove, some sand and gravel beaches / forests, grassy hills |
| 87 | Golfo de Montijo: Isla Leone | (Isla Leone): low mangroves, some sand and gravel beaches / hills and forest |
| 88 | Golfo de Montijo: Punta Camaron to Punta Icaco | mangrove-lined inlet / forest, fields |
| 89 | Punta Icaco to Santa Catalina | sandy beaches, some rocky points / scrubby forest and grassy hills |
| 90 | Santa Catalina to Punta Cativo | steep rocky shore with some sandy beaches / forested hills |
| 91 | Punta Cativo to Punta Roble | steep rocky shore with sandy beaches in bays / forested hills |
| 92 | Punta Roble to Punta Pajaron | steep rocky shore with sandy beaches in bays / hills |
| 93 | Punta Pajaron to Isla de La Corocita | sandy outer shore enclosing mangrove-lined inlets / forest |
| 94 | Isla de La Corocita to Punta Entrada | rocky shoreline / steep hills |
| 95 | Isla La Porcada estuary | mangrove-lined inlet with intertidal flats / grass and trees |
| 96 | Playa del Jobo (Isla Toro to Estero Cabuya) | sand beach / open scrub or palms, fields, low hills |
| 97 | Estero Cabuya | mangrove-lined inlet / open scrub or palms, fields, low hills |
| 98 | Playa San Lorenzo (Estero Cabuya to Punta Rincon) | gravel beaches / forest |
| 99 | Punta Rincon to Punta Boca Brava | rocky points, sandy beaches / partially cleared hills |
| 100 | Bahia de Muertos/Estero de Horconcitos | mangrove-lined inlet / forested ground and hills |
| 101 | Boca Brava estuary | mangrove-lined inlet / forested ground and hills |
| 102 | Isla Sevilla | sandy shoreline / low scrub, grassy areas with trees and forest |
| 103 | Boca de San Pedro estuary | mangrove-lined inlet / forested ground and hills |
| 104 | Golfo de Chiriqui (W) | ocean beach / dunes, grazing land, some trees, flat terrain |
| 105 | Puerto Armuelles | — not surveyed — Puerto Armuelles: docks and city |
| 106 | Bahia de Charco Azul | sand and gravel beaches with rocky sectors / flat forest or low scrubby hills |
| 107 | Punta Burica (to border with Costa Rica) | — not surveyed — |

Note: See Section 2.3 for an explanation of habitat descriptions.

with tall mangroves along the shoreline and palms and forest, with some swampy areas, inland. Mangrove stands along the shore are generally lower in Sectors 12 and 13, with hilly, forested country inland along the mainland stretches and forested areas on the lower-lying islands (Isla Cristobal).

### 4.2.3 Laguna de Chiriqui (Sectors 14–17) *(Map 4.1)*

The flooded mangrove shoreline backed by forest continues along the western shore of the Laguna de Chiriqui (Sector 14), with hills set back varying distances from the coast. The southern shore of the lagoon is much sandier (starting in Sector 15), with some stretches of narrow sandy beach with scattered tide wrack occurring to the west of Punta Cricamola in Sector 16; such areas attracted small numbers of shorebirds. The west shore of the Peninsula Valiente (Sector 17) consists of a mixture of sandy beaches, low, flooded, mangrove backed by forest, and steeper sections backed by forest towards the tip of the peninsula.

### 4.2.4 Golfo de los Mosquitos to Colon (Sectors 18–28) *(Maps 4.1 and 4.2)*

The outer headlands of the Peninsula Valiente (in Sector 18) are steep and rocky, although the eastern coastline of the peninsula facing the Golfo de los Mosquitos (Sectors 18 and 19) consists of a series of yellow/orange sandy beaches mixed with low forested points, some coral platforms, and forested hills behind. A very long sandy beach runs southeastward in Sector 20, backed by a broad forested plain containing the Laguna de Namani (the lagoon was not surveyed and is not thought to contain habitat suitable for Nearctic shorebirds).

The mountains of the Cordillera Central approach the coast again around the western end of Sector 21, and much of the terrain behind the shore in Sectors 21–23 consists of steep, heavily forested hills. Many of the beaches in Sector 21 are gravel rather than sand and are washed by a heavy surf. The coastline changes in Sectors 22 and 23, becoming rockier, with low clifflets or rocky points separating sandy beaches or coves. Similar habitats continue into Sector 24, which was not surveyed owing to adverse weather.

The mountains move away from the coast in Sector 24, and the hinterland is generally much flatter, although still heavily forested. Although stretches of sandy beach continue through Sectors 25–27, low rocky platforms and clifflets of reddish rock become much more common; some greenish wrack and obvious oil pollution were noted on the broad sandy beaches in Sector 27. The intertidal rocky platforms and low clifflets become more prominent in Sector 28 nearing Fort Sherman and the entrance to the harbour at Colon, where the northern terminus of the Panama Canal is located.

### 4.2.5 Central north coast: Colon to El Porvenir (Sectors 29–34) *(Map 4.3)*

The major feature of the central part of the Caribbean coastline of Panama between Colon and El Porvenir is the presence of extensive coral platforms, which form a broad, wet intertidal habitat along many sections of this part of the coast. Such habitats appeared to be used regularly by wading birds, but numbers of Nearctic shorebirds were very low.

To the east of Colon, in Sector 29, is a low-lying coastal inlet with coral platforms backed by low mangroves and forest/scrubby forest; an oil refinery and tanks occupy part of the shore between Cativa and Puerto Pilon. The coral platforms and low mangrove development continue through Sectors 30 and 31, with pockets of sandy beaches, and much of the hinterland is hilly and covered with heavy forest (Photo 5). A rather flat forested plain lies along most of the north coast in Sectors 32–34, with the shoreline consisting of a mixture of broad coral platforms and sandy beaches, with some rocky points with palms and other kinds of forest.

### 4.2.6 San Blas coastline (Sectors 35–50) *(Maps 4.3 and 4.4)*

Coral platforms, sandy beaches, rocky stretches, and low mangrove development continue as prominent habitats along the eastern section of the north coast of Panama, and some intertidal muddy habitats are found along the shore near Ustupo. The mangrove stands on this section of coast, as in the previous section along the north-central coast, are generally low and stunted compared with mangroves along the Pacific coast, a reflection of the less suitable substrates and comparatively lower productivity of the coastline.

A mixture of sandy beaches and low mangrove dominates the coastline in Sectors 35–37. Heavy palm forests cover much of the country inland; low hills are found in Sectors 35 and 36, whereas the terrain is flatter in Sector 37. The low mangrove- and palm-fringed islands of the Archipielago de San Blas lie offshore in Sector 37 and sectors eastward.

In addition to continuing sections of sandy beach and low mangrove, coral platforms are again found in Sectors 38–40, with some rocky points. Inland, there is heavy palm forest leading back to forested hills. Rather similar habitats occur through Sectors 41–43, with the emergence of some hilly promontories starting in Sector 42, where the mountains come closer to the coast.

Some of the only muddy intertidal areas found on the eastern stretch of the Caribbean coast occur on the nearshore islands just northwest of Ustupo near Ustupo Obodsucum (Sector 44) (Photo 6). The muddy areas are quite restricted in extent, and no shorebirds were found on them.

The low-lying coast with mixtures of coral platforms and sand beaches backed by low forested terrain continues through Sectors 45 and 46, with the shoreline becoming much hillier east of Caledonia in Sector 47. The coast becomes steeper and rockier in Sector 48, with forested hills behind coves with sandy and pebbly beaches. A long stretch of wave-washed sandy beach with a gravelly crest, backed by palm forests and hills, runs down to Puerto Obaldia (Sector 49), where the surveys of the Caribbean coast ended. The coast beyond Puerto Obaldia to the border with Colombia at Cabo Tiburon (Sector 50, not surveyed) is steep and hilly.

## 4.3 Pacific coast (Sectors 51–107) *(Maps 4.5–4.8)*

Compared with the Caribbean coast, the Pacific coast of Panama contains a greater range of coastal habitats suitable for shorebirds and other waterbirds. The Golfo de Panama, in particular, contains extensive areas of intertidal mudflats and sandflats. Mangrove-lined river estuaries are found around the Golfo de San Miguel and in Bahia de Chame, and mangrove coasts are also found east of Panama City and along the coastlines of the Bahia de Parita, where

many salt evaporation pans and areas of open mud are found behind the outer shoreline. Long stretches of sandy beach are found running southwest from Punta Chame. The Golfo de Montijo contains extensive areas of mangroves and mudflats; in the west of the country, the coastline of the Golfo de Chiriqui contains a series of mangrove-lined inlets as well as long sections of sandy beaches. Steep mountainous shores are found on the southern part of the Pacific coast towards the border with Colombia and around the outer parts of the Peninsula de Azuero.

### 4.3.1 Colombian border to Punta Garachine (Sectors 51–54) *(Map 4.5)*

This section of coast consists principally of steep, forested rocky mountain slopes. A small area of muddy flats is found in the estuary of the Rio Jacque in Sector 52. Sandy beaches occur in several types of locations, including the shoreline enclosing the Rio Jacque estuary, other smaller barrier types of beach found at river exits, and, to a more limited extent, steep coves or inlets along the coast. Elsewhere, the coast is steep and rocky.

### 4.3.2 Golfo de San Miguel (Sectors 55–57) *(Map 4.6)*

A number of major rivers enter the bay systems that make up the Golfo de San Miguel, including the Rio Sambu, Rio Tuira, Rio Sabana, Rio Cucunati, and Rio Congo.

The north side of Ensenada de Garachine (Sector 55) from Punta Patino to Punta Cueca is rocky with small pocket sandy beaches. Mudflats, with some sandy stretches, line the inner part of the bay from Punta Cueca to Punta Santa Barbara past the town of Garachine in the southern part of the bay, where a few rocky outcrops occur. Low mangroves are found around the inner shoreline of the bay, and the Rio Sambu enters the bay to the east of Garachine.

Mudflats backed by low mangroves occur in the middle of Sector 56 between Punta Alegre and Punta Blanca, with rockier sections at the northern and southern ends of the sector backed by forested slopes. The inner part of the Rio Tuira estuary above La Palma does not appear to have any intertidal habitats along the riverbanks and was not surveyed.

Many rivers enter the northern part of the Golfo de San Miguel in the Ensenada de Pena Hueca (Sector 57), and the terrain is low-lying and forested, with the shoreline covered with low mangroves. Mudflats occur around some of the points in the inner parts of the bay, although tidal conditions were high during all the surveys, with the water flooding under the mangroves.

### 4.3.3 East side of Golfo de Panama (Sectors 58–60) *(Map 4.6)*

Some sandy beaches backed by grassy scrub and forest are found around Punta Brava at the southern end of Sector 58, but much of the remainder of the sector is low and rocky, with some small beaches and steep forested hillsides rising from the shoreline. Fairly extensive intertidal flats are found in Sectors 59 and 60. Much of Sector 59 to the north of Punta Bruja, a low forested promontory, is sandy, with rippled sandflats and some areas with dead stands of mangroves and sandy beaches. Mudflats and sandflats with mangroves and sandy beaches are found in the north of Sector 60 (Photo 2), whereas sandy beaches and flats are found around Chiman. The bays are lined with mangroves.

### 4.3.4 Bahia de Panama (Sectors 61–63) *(Map 4.6)*

Sectors 61 and 62 contain the most important habitats for shorebirds in Panama. There are extensive areas of intertidal flats, which may reach several kilometres in width and which are composed of a variety of substrate types, ranging from flat, soft, soupy mud, through heavily channelled mud, to tougher mudflats and firm sandflats. Some sections of the coast are backed by mangrove forest, whereas others have sandy beaches backed by forest, open scrub, or agricultural land. Such areas provide highly suitable combinations of productive feeding areas and roosting areas for shorebirds.

Most of the eastern part of Sector 61 is backed by heavy mangrove forests, and extensive mudflats are found in the bays. The coastline straightens at the point west of Isla Cocotillo, and a mixture of soft mudflats and heavily channelled mudflats, backed by mangroves and some areas of tougher mud or sand on the upper shore, runs northwestward (Photo 3). Sandier sections backed by low scrub and forest are found around the junction of Sectors 61 and 62. Huge mudflats run eastward from Panama City/Panama Viejo. They are composed again of areas of soft (Photo 7) and firm mud, with and without channelling. The upper flats may consist of tougher sections of mud or a narrow sandy beach, and much of the terrain behind the shore east of Panama City consists of low, flat agricultural land or forested foreshore. The shoreline around Panama City itself is heavily developed and urbanized, and this sector (Sector 63), which includes the mouth of the Panama Canal, was not surveyed. The sector contains both rocky shoreline and mudflats, although most intertidal areas are considered to be rather heavily polluted.

### 4.3.5 West Bahia de Panama/Bahia de Chame (Sectors 64–65) *(Map 4.6)*

Quite extensive mudflats and sandflats run south between Punta Salazar/Bahia Vacamonte and Punta San Juanito, backed by agricultural land and hills (Sector 64). A series of points with sheltered beaches is found at the northern side of the Bahia de Chame (Sector 65), which is enclosed by the long, sandy promontory of Punta Chame on its south side. The bay contains extensive mudflats (Photo 8) and stands of mangroves in its inner reaches, and smaller mudflats and mangroves have developed along the inside of the promontory; some shrimp ponds are found behind the shoreline.

### 4.3.6 West Golfo de Panama shoreline (Sectors 66–68) *(Map 4.7)*

Long sandy ocean beaches stretch south from Punta Chame to the northern part of Bahia de Parita (Sectors 66–68). Low shrubby forest and shrimp ponds are found behind the beach along the Peninsula de Chame. Low sandy clifflets are found behind the beach along some stretches of coast, and the interior is made up of gently rolling countryside consisting of open scrubby forests or agricultural land (Photo 4).

#### 4.3.7 Bahia de Parita (Sectors 69–70) *(Map 4.7)*

Extensive mudflats and sandflats, extending for up to several kilometres in width, are found in the Bahia de Parita, which is fringed with a belt of mangrove forest running along the upper shoreline. Inland are found very extensive open areas of mud as well as commercial shrimp ponds and salt evaporation pans. This combination of habitats (Photo 9) attracts large numbers of shorebirds to the area.

#### 4.3.8 East coast Peninsula de Azuero (Sectors 71–74) *(Map 4.7)*

The east coast of the Peninsula de Azuero between Bahia de Parita and Punta Mala consists primarily of sandy beaches backed by scrub, forest, and agricultural land. A few rivers form small estuaries along the coast.

#### 4.3.9 South coast Peninsula de Azuero (Sectors 75–80) *(Map 4.7)*

Sand and gravel beaches backed by open grassy areas and agricultural land continue westward from Punta Mala in Sector 75, although the coastline becomes steeper in Sector 76, with rocky points separating sandy bays. In Sector 77, a sandy barrier beach encloses a small mangrove-lined estuary surrounded by grassy and agricultural land at Isla de Canas. The coastline is steeper again in Sectors 78–80, with rocky shores rising to hills covered with extensive open grassy areas as well as forests; some stretches of sandy, or in the western part gravelly, beaches are found between the headlands.

#### 4.3.10 West coast Peninsula de Azuero (Sectors 81–82) *(Map 4.7)*

The coast remains rocky and steep into Sector 81, with some sand and gravel beaches found between grassy hills and rocky points. The coastline becomes flatter towards Sector 81, with some mangrove-lined inlets at the mouths of broad river plains, as well as a succession of sandy beaches and rocky points.

#### 4.3.11 Golfo de Montijo (Sectors 83–88) *(Maps 4.7 and 4.8)*

The hills that reach the coast around Punta Duarte produce rocky promontories and sandy beaches, as well as eroded, "badland" topography at the southern end of Sector 83. The topography is flatter in the northern part of the sector, with sand or pebbly beaches backed by low swampy areas, open forested lowland, agricultural land, and palm outcrops. The inner parts of the Golfo de Montijo (Sectors 84–88) are lined with either low or tall mangroves, backed by forests and grassy hills. Tide conditions were high during the surveys, but there appeared to be some mudflats in Sectors 84 and 85, and sand and gravel beaches were noted in Sector 86. Sand and gravel beaches also occur around the coast of Isla Leone (Sector 87), as well as low mangroves in the northwest of the island.

#### 4.3.12 Canal de Bahia Honda coastline (Sectors 89–91) *(Map 4.8)*

The coastline around Punta Brava is fairly flat, with sandy beaches and forest running down to the point and rocky points separating sandy beaches and coves backed by low scrubby country to the west of the point. Beyond Santa Catalina to Bahia Honda (Sectors 90 and 91), the mountains reach the coast, and the shoreline is generally steep, rocky, and forested, with occasional sandy beaches in coves.

#### 4.3.13 Golfo de Chiriqui (Sectors 92–107) *(Map 4.8)*

A number of tidal inlets are found along the coastline of the Golfo de Chiriqui, many of them containing expanses of intertidal flats and stands of mangroves. The inlets are often separated by long stretches of sandy beaches or rocky shoreline (Photo 10).

The steep rocky forested shoreline with pocket sandy beaches continues in Sector 92 between Bahia Honda and Punta Pajaron. The terrain becomes flatter at Punta Pajaroncita in Sector 93, which marks the entrance to the mangrove-lined estuary of the Rio Lovaina and Rio Bubi. The estuary is enclosed by the low sandy Isla de La Corocita, whose outer shoreline forms a long ocean beach backed by flat, open scrubby country. Another small, sandy, mangrove-lined inlet is found at the northern end of this sector. Sector 94 comprises a rocky, steep outer coastline with boulder and gravel beaches.

Sector 95 comprises the estuary enclosed by the Isla La Porcada. A mixture of low and tall mangroves lines the estuary, which is backed by hills. Tide conditions were high during the surveys, with the water well into the mangroves. A long section of sandy ocean beach, the Playa del Jobo, backed by open grassy areas, scrub, or forest, runs through Sector 96 from Isla Toro to Estero Cabuya (Photo 10). Estero Cabuya (Sector 97) is also lined with mangroves, which are flooded at high tide.

Many of the beaches in Bahia de San Lorenzo in Sector 98 are gravel and backed by scrub or forest; the mangrove-lined river estuary near the beginning of the sector was not surveyed (Photo 10). Low cliffleets of reddish rock and sand beaches also occur in the western half of the sector. Sector 99 comprises the outer coastline of the mainland and islands of the Ensenada de Bejuco and Isla Boca Brava. Sandy beaches are found on the peninsula at the west end of the Bahia de San Lorenzo and on parts of Isla Boca Brava, but much of the remaining coastline on the islands is rocky.

Sector 100 comprises the fairly large inlets of Bahia de Muertos and Estero de Horconcitos. Mangroves line the shores of the estuary, which are fully flooded at high tide; forested ground leads back to hills. Sector 101 comprises the western end of the same estuarine complex, around the Isla Mono, Isla Boquita, and Isla Chalapa. The outer shoreline of Isla Sevilla, the Playa Las Pavas, is again sand beach, backed by forest or open areas of grass and scrub. The Boca de San Pedro, comprising Sector 103, forms another estuarine complex that appears to be connected with Sector 101. The area is again heavily lined with mangroves, and flocks of shorebirds were found on intertidal flats that were exposed off the points of the islands in the complex.

A very long stretch of ocean beaches and dunes backed by open grassy areas (Sector 104) runs from the Boca de San Pedro to Puerto Armuelles. A few rivers enter the coast and may enclose small mangrove-lined inlets, such as La Boca de Los Espinos. Sector 105 comprises the harbour and developed shoreline of Puerto Armuelles, a major export centre for bananas, and was not surveyed.

Some gravel beaches backed by forested hillsides are found on the inner parts of the coastline of the Peninsula Burica (Sector 106), but most of the shoreline consists of sandy beaches, behind which are found low forested country, palms, or low hills with grass or grazed scrub. Similar coastline continues in Sector 107 (not surveyed) to the border with Costa Rica.

**Photo 1**
Coast of Isla Popa, an island of the Archipielago de Bocas del Toro bordering Bahia Almirante in northwestern Panama (Sector 9). Much of the shoreline consists of low, flooded, scrubby mangrove, with little muddy or other intertidal habitat.

**Photo 2**
Upper intertidal zone and shoreline on the northeastern shore of the Golfo de Panama (Sector 60). The intertidal zone consists of a mixture of mudflats and sandflats, here partly covered by water, backed by a mixture of mangroves and sandy beaches, with low forest inland.

**Photo 3**
Bahia de Panama shoreline in the northern Golfo de Panama east of Panama City (Sector 61). Extensive mudflats, with creeks and channels, are backed by mangrove forests.

**Photo 4**
Extensive sandy beaches along the western shore of the Golfo de Panama between Punta Chame and Bahia de Parita (Sectors 66–68), with occasional river outlets and low sandy clifflets. Inland, there is gently rolling terrain consisting of open scrubby forest or agricultural land.

**Photo 5**
Coral platforms with some low mangrove development and sandy beaches, a feature of the central part of the northern coast between Colon and El Porvenir (Sectors 29–34). The hinterland in Sectors 30–31 (see photo) consists of heavily forested hills, which give way to a low forested plain towards El Porvenir.

**Photo 6**
A few of the nearshore islands along the San Blas coastline in northeastern Panama near Ustupo Obodsucum (Sector 44), containing some of the only patches of muddy habitat found in this region.

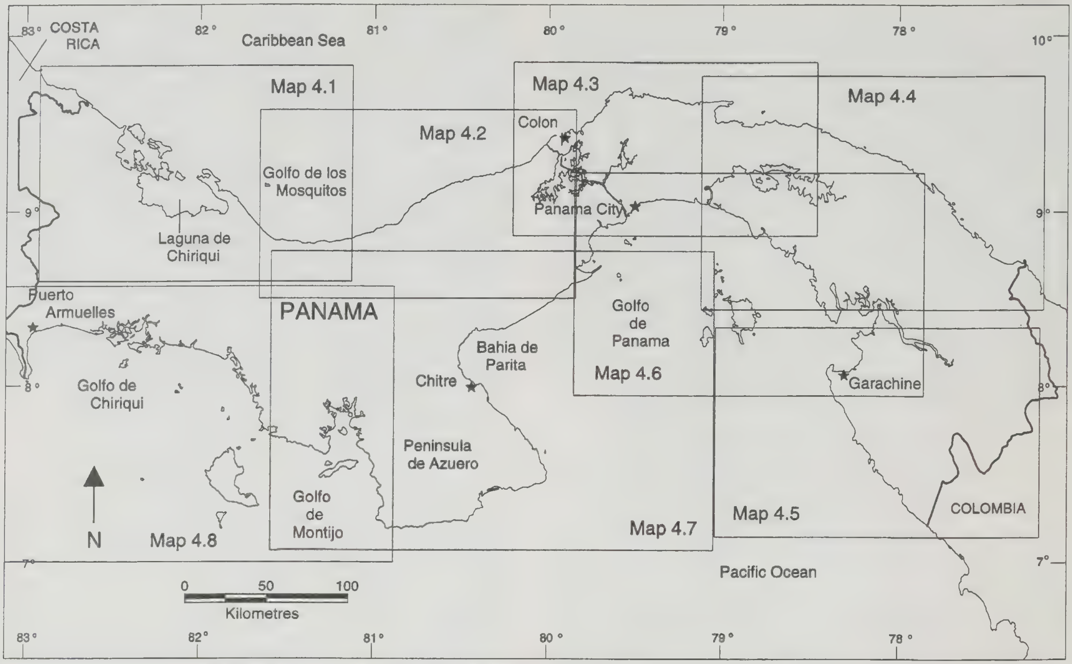
**Photo 7**
Some of the most important habitats for shorebirds in Panama, east of Panama City. Huge expanses of soft mudflats, which may or may not be scored by channels, provide extensive feeding areas, while a zone of firmer mud and stretches of sandy beach provide roosting areas along the shoreline. Low forested terrain or agricultural land is found inland.

**Photo 8**
The interior parts of Bahia de Chame (Sector 65), which contain extensive areas of intertidal flats backed by mangrove forest.

**Photo 9**
Coastline of Bahia de Parita, looking southwards at the entrance of Rio Santa Maria. Extensive areas of open mud, as well as shrimp ponds and salt evaporation pans, are found inland, separated by a belt of mangrove forest from the broad intertidal flats occurring in the bay.

**Photo 10**
Long ocean beaches and mangrove-lined river estuaries found along the Pacific shoreline of the Golfo de Chiriqui in western Panama. The photograph shows the ocean beaches of Sector 96 in the distance, with the mangrove-lined Estero Cabuya (Sector 97) in the middle ground and another small river estuary (not surveyed) and ocean beaches in Sector 98 in the foreground.

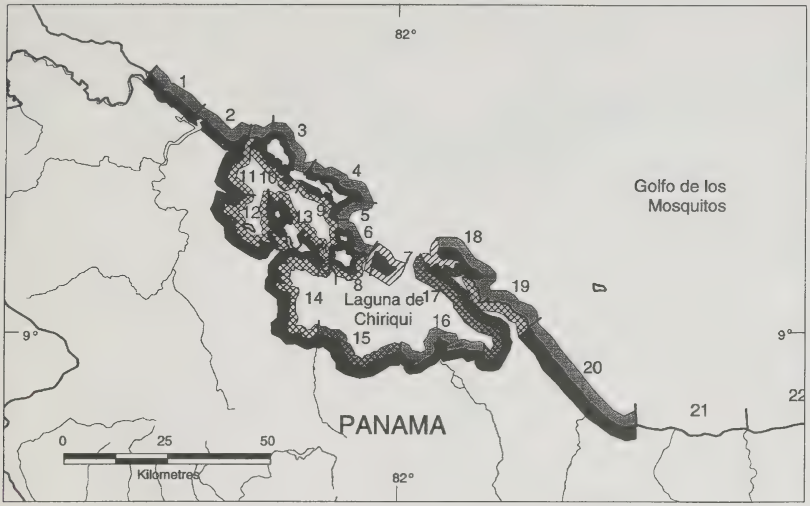
**Map 4 Index**
Map index showing locations of Maps 4.1–4.8, illustrating habitats found along the Caribbean and Pacific coasts of Panama. Survey sectors (1–50 Caribbean coast, 51–107 Pacific coast) run clockwise around the country, starting at the west end of the northern coast.



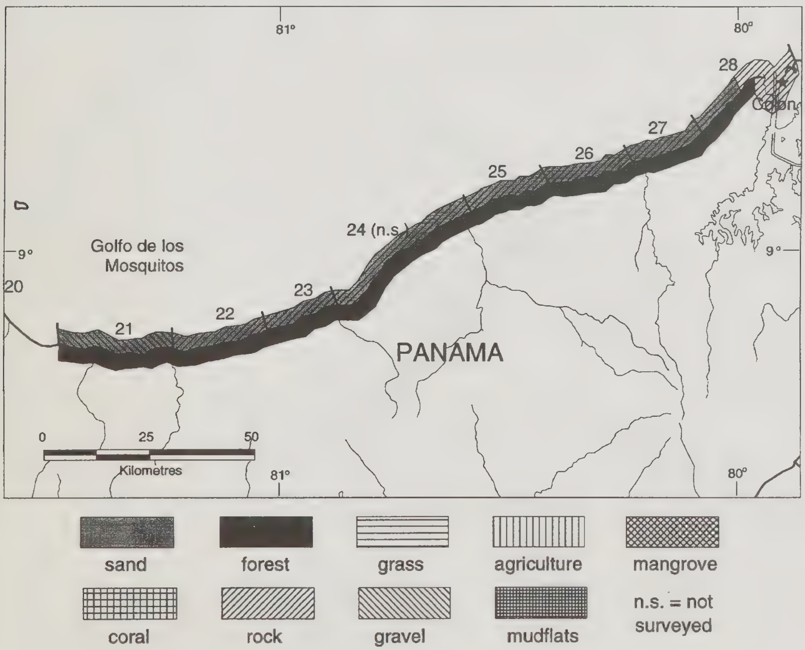

## Chapter 4 Notes on Map Legends

The principal habitats occurring in survey sectors illustrated in Maps 4.1–4.8 are identified in the legends below the maps. Two bands of habitats are shown: the band on the seaward side illustrates the principal shoreline and/or intertidal habitats occurring in the survey sector, whereas the band on the landward side illustrates the major habitats found behind the shoreline. Where a single habitat predominated in the sector, a single shading or hatching pattern appears in the appropriate band (e.g., sand beach backed by forest in Sector 1, Map 4.1). Where a mixture of habitats occurred within the sector, hatching and shading patterns are overlaid (e.g., sandy beaches [light shading] alternating with rocky points [diagonal hatching] along the shore, backed by forest [dark shading] in Sector 22, Map 4.2). In these cases, the overlaying of more than one habitat type indicates simply that both types were present, and no attempt has been made to indicate the actual distribution of the habitat types within the sector.

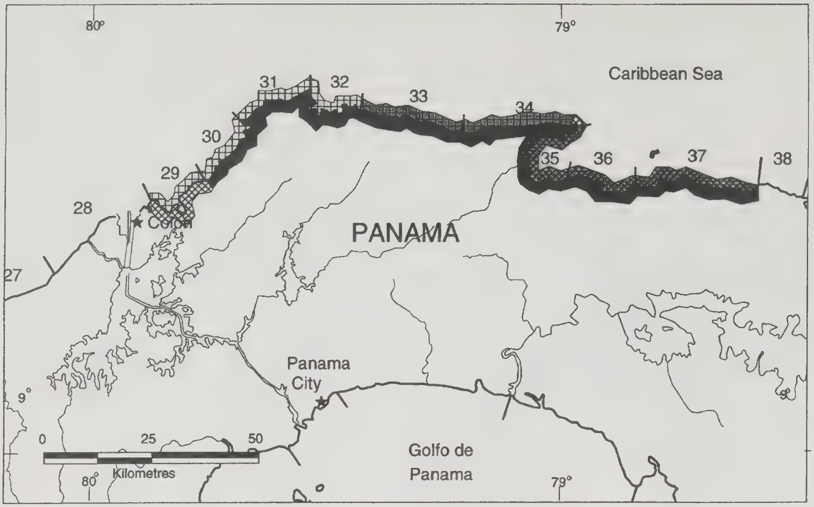
**Map 4.1**
Habitats along the northwest Caribbean coast of Panama, Laguna de Chiriqui, and Golfo de los Mosquitos (Sectors 1–20)



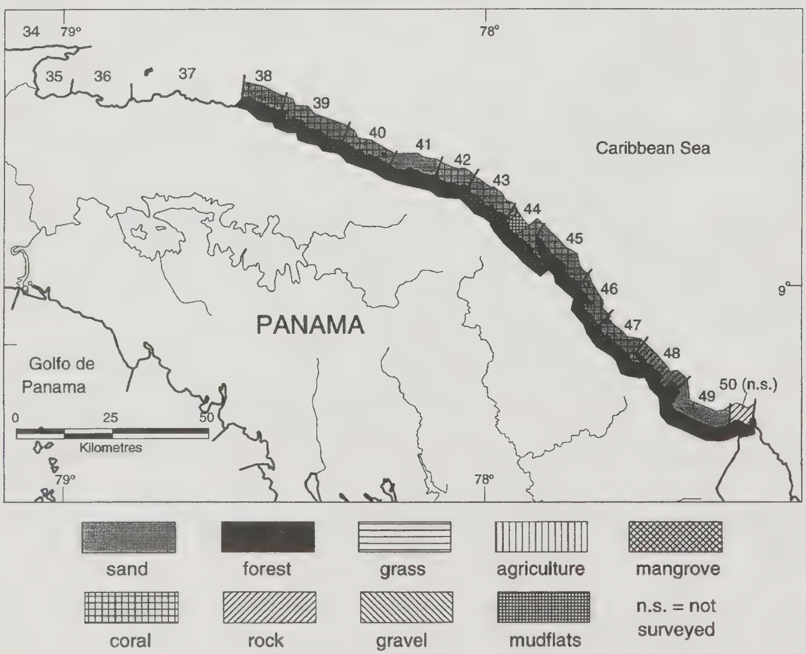

**Map 4.2**
Habitats along the Caribbean coast of Panama, Golfo de los Mosquitos (Sectors 21–28)



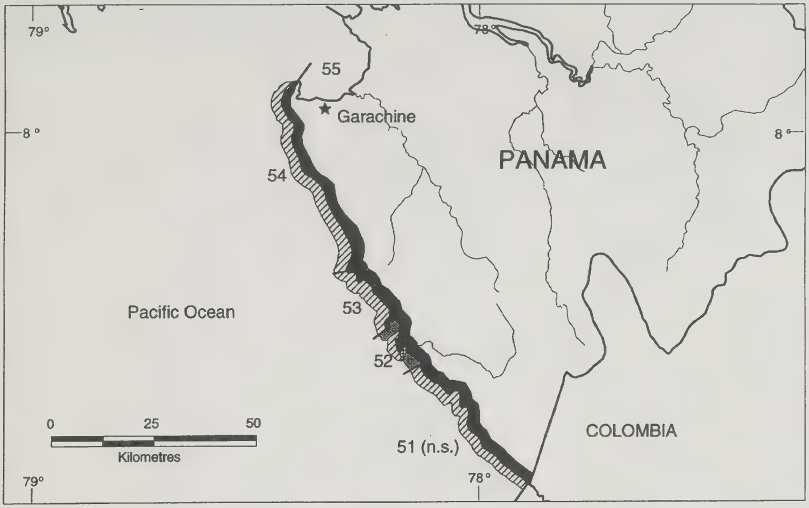
**Map 4.3**
Habitats along the north-central Caribbean coast of Panama (Sectors 29–37)



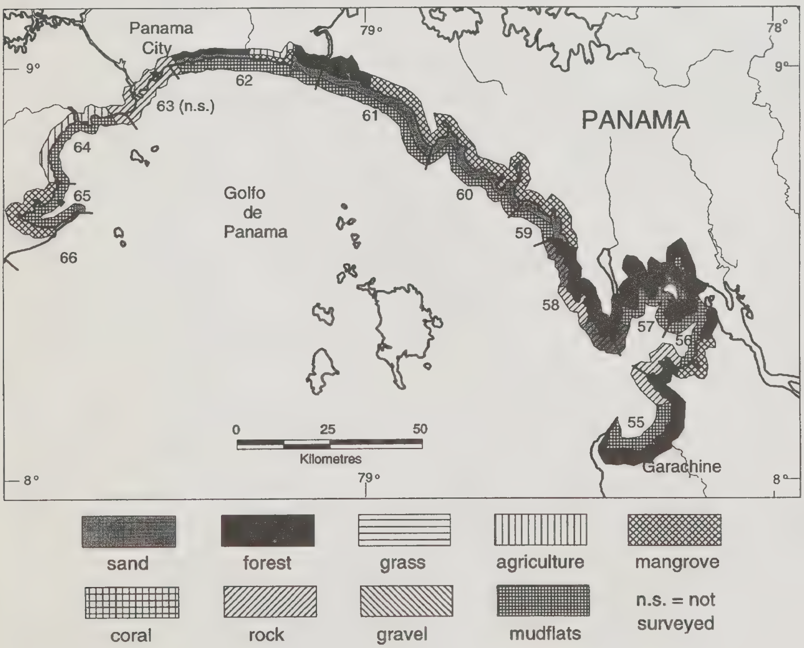

**Map 4.4**
Habitats along the eastern Caribbean coast of Panama (Sectors 38–50)



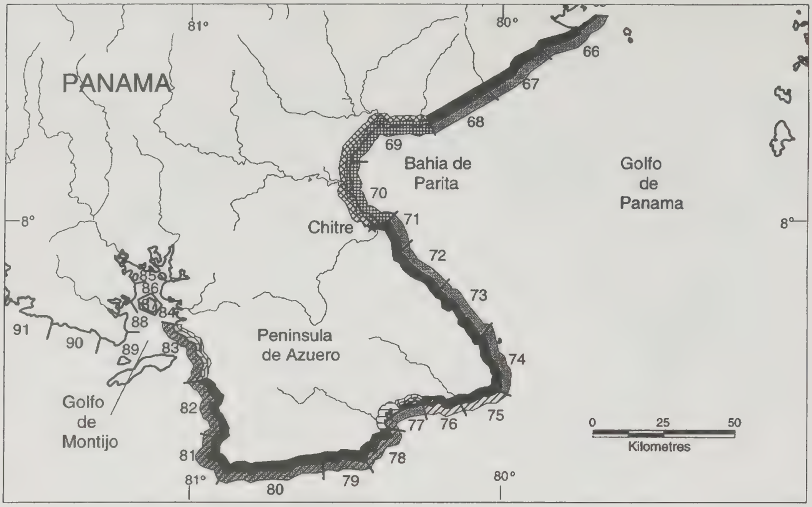
**Map 4.5**
Habitats along the eastern Pacific coast of Panama (Sectors 51–54)



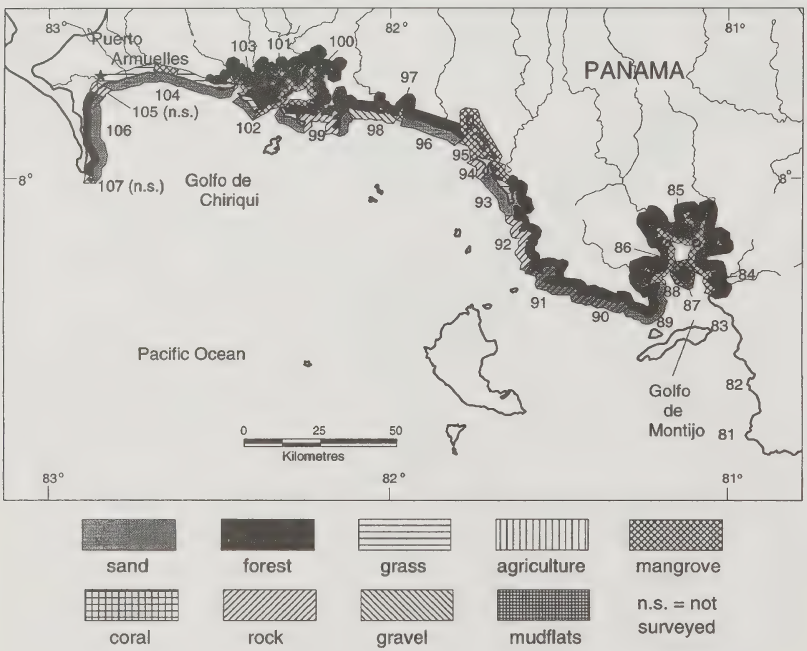

**Map 4.6**
Habitats along the Pacific coast of Panama, eastern and central Golfo de Panama (Sectors 55–65)



**Map 4.7**
Habitats along the Pacific coast of Panama, western Golfo de Panama, and Peninsula de Azuero (Sectors 66–83)




**Map 4.8**
Habitats along the western Pacific coast of Panama, Golfo de Montijo, and Golfo de Chiriqui (Sectors 84–107)



# *Chapter 5*
# The distribution and abundance of Nearctic shorebirds on the coast of Panama

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The Pacific coastline of Panama contains a number of internationally important wetlands, some of which are of considerable significance to populations of Nearctic shorebirds (Delgado 1986). Little detailed information exists, however, on the abundance or distribution of Nearctic shorebirds either within these areas or on other less well known parts of the Pacific coast, and little information is available from the Caribbean coast. This chapter presents information on the distribution and abundance of Nearctic shorebirds gathered during surveys of the entire coast of Panama in January 1993 and during surveys of the coastline of the Golfo de Panama in February 1988 and October 1991.

## 5.1 Overall patterns of shorebird distribution

### 5.1.1 Pacific and Caribbean coasts, January 1993

*Maps 5.1, 5.5, 5.10; Tables 5.1–5.5*

A total of some 255 000 shorebirds was counted during surveys of the entire coast of Panama in January 1993. By far the majority (254 000 or 99.8%) of the birds were seen on the Pacific coast of Panama, only 470 (0.2%) being recorded on the Caribbean coast. Small shorebirds, mostly Western Sandpipers *Calidris mauri* (see Section 5.2), were numerically dominant, making up 236 000 (92.8%) of the total shorebirds seen. Medium-sized species were less numerous (total 12 300, 4.8% of all shorebirds seen), and large species less numerous still (total 6200, 2.4% of all shorebirds seen).

The relative proportions of the different size classes occurring on the Pacific and Caribbean coasts were quite different. Whereas small species dominated other size classes numerically on the Pacific coast (92.9% vs. 4.8% vs. 2.4% for small vs. medium-sized vs. large shorebirds, respectively, as a percentage of the Pacific coast overall total), the proportions of the different size classes were much more equal on the Caribbean coast (33.8% vs. 35.9% vs. 30.2%, respectively, as a percentage of the Caribbean coast overall total). Species compositions of each size group were also rather different on the two coasts. On the Pacific coast, unidentified small shorebirds ("peeps") far outnumbered Sanderling *Calidris alba* and Spotted Sandpipers *Actitis macularia*. In contrast, on the Caribbean coast, only one flock of 30 peeps was seen in Sector 34 to the west of El Porvenir, this category being outnumbered by both Sanderlings (61) and Spotted Sandpipers (69). Among medium-sized shorebirds, dowitchers and yellowlegs were not recorded at all during the aerial surveys on the Caribbean side, nor were Black-necked Stilts *Himantopus mexicanus* or oystercatchers among the large species, although most of these species are thought to occur on both coasts (Ridgely and Gwynne 1989). These differences appear to reflect the differences in habitat and likely availability of food resources on the two coasts: the Caribbean coast does not have the extensive areas of intertidal mudflats favoured by small sandpipers and other shorebirds on the Pacific coast, and it is possible that the coral platforms and other more limited intertidal habitats occurring on the Caribbean coast provide less abundant food resources of a size and type required by the smaller species.

For the limited numbers of shorebirds observed on the Caribbean coast, the most important areas were the shores of the Laguna de Chiriqui (mainland, Sectors 14–17; islands, Sectors 7–8): these sectors held 320 of the 470 birds (68.1%) on the Caribbean side. Smaller numbers of Sanderlings and Spotted Sandpipers occurred along the sandy shores of the Golfo de los Mosquitos (Sectors 18–29), and the coast around El Porvenir (Sectors 34 and 35) also supported small numbers of shorebirds.

The most important areas for shorebirds in Panama were found on the Pacific coast in the northern part of the Golfo de Panama (Bahia de Panama) to the east of Panama City (Sectors 61 and 62). These two sectors held some 210 000 shorebirds, comprising 82.3% of the shorebirds counted in Panama. The area was especially important for the small species, mainly Western Sandpipers, with 86.8% of the Panamanian total, and there were also substantial numbers of medium-sized and large species (18.6% and 37.6% of the Panamanian totals, respectively). The Bahia de Parita (Sectors 69 and 70), with its associated salt pans and shrimp ponds, was also very important, holding 10 800 shorebirds (4.2% of the Panamanian total); it was especially important for medium-sized species (particularly dowitchers), with some 51.5% of the Panamanian total, and large species (8.5% of the Panamanian total). Two other parts of the western Golfo de Panama held significant numbers of shorebirds: the Bahia de Chame (Sector 65, total 7900, 3.1% of the Panamanian total) and the flats west of Panama City running north from Punta San Juanito (Sector 64, total 6700, 2.6% of the Panamanian total). Small sandpipers tended to predominate in both areas, although notable numbers of medium-sized shorebirds (800, 6.5% of the Panamanian total) were found in Sector 65. In the east of the Golfo de Panama, the bays in the Golfo de San Miguel (Sectors 55–57) were also

important, especially the Ensenada de Garachine (Sector 55), which held almost 7900 shorebirds, including significant numbers of large species (1300, or 21.3% of the Panamanian total), consisting of Willets *Catoptrophorus semipalmatus* and Whimbrel *Numenius phaeopus*.

Modest concentrations of shorebirds were found in the Golfo de Montijo (Sectors 84–88) (total 1900, 0.7% of the Panamanian total), which was of relatively greater importance for large (770, 12.4% of the Panamanian total) and medium-sized (660, 5.3% of the Panamanian total) shorebirds than for the smaller species (460, 0.2% of the Panamanian total). Some of the inlets and estuaries along the coast of the Golfo de Chiriqui held small to moderate concentrations of shorebirds, the largest numbers being found in the Boca de San Pedro estuary (Sector 103, total 3200, 1.3% of the Panamanian total). The sandy beaches of the Golfo de Chiriqui were also important for Sanderling (see below).

#### 5.1.2 Golfo de Panama, February 1988 and October 1991

*Table 5.6*

The highest number of shorebirds found in the Golfo de Panama during the three sets of surveys (February 1988, October 1991, and January 1993) occurred in October, during the period of southward migration of the Western Sandpiper, when over 369 000 shorebirds were counted. The lowest total occurred in February 1988: over 185 000 shorebirds were counted at a time when many birds may be moving northwards (Delgado and Butler 1993). The total of some 247 000 shorebirds during the wintering period in January was intermediate.

The general pattern of distribution of shorebirds in the Golfo de Panama was fairly similar during the three surveys. By far the most important area was the coastline east of Panama City, with the two most important sectors (Sectors 61 and 62) holding 90.2%, 84.9%, and 81.0% of the shorebirds in October, January, and February, respectively. In all three seasons, other important areas included the Bahia de Parita coastline and wetlands, Bahia de Chame and the flats west of Panama City, and the bays of the Golfo de San Miguel.

### 5.2 Small shorebirds

*Maps 5.1–5.4; Tables 5.2, 5.3, 5.6*

The most abundant group of species in the small shorebird size category consisted of small sandpipers in the genus *Calidris*, often collectively referred to as "peeps." Although it is not always possible to identify these species individually during aerial surveys, banding and ground studies have indicated that the overwhelming majority in Panama consist of Western Sandpipers, with much smaller numbers of Semipalmated Sandpipers *Calidris pusilla* and Least Sandpipers *C. minutilla* (Delgado and Butler 1993). Semipalmated Plovers *Charadrius semipalmatus*, which are fairly common in Bahia de Parita (Delgado and Butler 1993), will also have been included in the "unidentified small shorebird" category during the aerial surveys. Spotted Sandpipers can normally be identified from the air when seen alone or in small numbers but would also be included in the unidentified category when present in flocks of much larger numbers of small sandpipers.

#### 5.2.1 Unidentified small shorebirds (mostly Western Sandpipers *Calidris mauri*)

##### 5.2.1.1 Pacific and Caribbean coasts, January 1993

*Map 5.2; Table 5.3*

A total of some 235 000 unidentified small shorebirds was counted during the surveys in January 1993. By far the largest concentrations were found in the two survey sectors (Sectors 61 and 62) extending some 84 km eastwards from Panama City. Both sectors contained extensive intertidal mudflats of a variety of substrate types (see Chapter 4) and backed by firm sediments or sandy beaches, providing an excellent combination of productive feeding areas and roosting sites. These two zones together held 87.2% (205 000) of the total unidentified small shorebirds, with linear densities of nearly 970 birds/km in Sector 61 and over 3760 birds/km in Sector 62 (Appendix 1).

A number of other important areas were identified for small sandpipers (unidentified small shorebirds), although both numbers and densities were lower in these locations. On the west side of the Golfo de Panama, at Bahia de Chame (Sector 65), 7000 (3.0% of the Panamanian total) small sandpipers were recorded along the mudflats lining the northern side of Punta Chame; extensive mudflats and mangroves are found around the inner parts of this bay. The flats running north from Punta San Juanito to the west of Panama City (Sector 64) supported 6700 small sandpipers (2.8% of the Panamanian total); most were observed roosting near mangrove areas. At Bahia de Parita (Sectors 69 and 70), some 4000 (1.7% of the Panamanian total) small sandpipers were found in the extensive areas of open mud, salt pans, and shrimp ponds situated behind the tidal flats and coastal mangroves. Large numbers of shorebirds, including calidridine sandpipers, are known to use this area during winter and migration periods (Delgado and Butler 1993). On the east side of the Golfo de Panama, 6300 (2.7% of the Panamanian total) small sandpipers were counted on the flats of the Ensenada de Garachine in the Golfo de San Miguel (Sector 55).

The only concentration of small sandpipers found in the western part of Panama involved a total of some 2700 (1.1% of the Panamanian total) birds in the Boca de San Pedro estuary (Sector 103) on mudflats lining the bay. Few shorebirds were found in other inlets off the Golfo de Chiriqui in the western part of the country — although tidal conditions were high during surveys, so few or no intertidal areas were exposed — or in the Golfo de Montijo on the west side of the Peninsula de Azuero.

##### 5.2.1.2 Golfo de Panama, February 1988 and October 1991

*Table 5.7*

Patterns of distribution of small sandpipers within the Golfo de Panama during surveys in October 1991 and February 1988 were broadly similar to those observed during the wintering period in January 1993. Sectors 61 and 62 east of Panama City were of outstanding importance in each season. Sectors 55–57 in Bahia de San Miguel near Garachine were more heavily used in February than during southward migration in October, as were Sectors 64 and 65 west of Panama City, although more shorebirds were found in Bahia de Parita (Sector 70) near Chitre in October than in February.

### 5.2.2 Spotted Sandpiper *Actitis macularia*

5.2.2.1 Pacific and Caribbean coasts, January 1993

*Map 5.3; Table 5.3*

A total of 108 Spotted Sandpipers was identified during the January 1993 surveys. The distributional pattern was different from that of other species, in that more birds were counted on the Caribbean coast (69) than on the Pacific coast (39). On the north coast, the largest concentrations were found in the Laguna de Chiriqui, where 46 (42.6% of the Panamanian total, 66.7% of the Caribbean coast total) were observed. Smaller numbers were scattered elsewhere along the north coast, particularly near Colon. On the Pacific coast, the largest numbers were observed in the Golfo de Montijo, although the total in these sectors (Sectors 84–88) amounted to just 10 birds. It seems likely that many more Spotted Sandpipers occur along muddy coastlines in the Golfo de Panama than is indicated on Map 5.3 and in Table 5.3 and that the small numbers observed may have resulted from the species not being distinguished in larger flocks of small shorebirds occurring in these areas.

5.2.2.2 Golfo de Panama, February 1988 and October 1991

*Table 5.7*

Small numbers of the species were seen in the surveys of the Golfo de Panama in February 1988 and October 1991.

### 5.2.3 Sanderling *Calidris alba*

5.2.3.1 Pacific and Caribbean coasts, January 1993

*Map 5.4; Table 5.3*

A total of some 1000 Sanderlings was observed on the January 1993 surveys, most (950, 94.0%) occurring on the Pacific coast. On the Caribbean side, all but one of the Sanderlings were seen on the sandy beaches of the Laguna de Chiriqui (Sector 16) and of the Golfo de los Mosquitos (Sector 20). On the Pacific coast, the largest numbers were seen on the ocean beaches in the west of the country along the Golfo de Chiriqui (590 in Sectors 93–107, 58.4% of the Panamanian total, 62.1% of the Pacific coast total), with the largest concentration of 320 (9.1 birds/km, Appendix 1) occurring on the Playa del Jobo (Sector 96). One hundred and seventy Sanderlings were found on the sandy beaches opposite Isla Chepillo in Sector 61 east of Panama City. Smaller numbers were scattered on the sandy beaches on the west coast of the Golfo de Panama south of Punta Chame and on the east and south coasts of the Peninsula de Azuero.

5.2.3.2 Golfo de Panama, February 1988 and October 1991

*Table 5.7*

Numbers of Sanderling found in the Golfo de Panama in February 1988 (220) were similar to those observed during winter surveys in January 1993 (220), with somewhat larger totals occurring during southward migration in October 1991 (340). In February 1988, the majority of the total of 220 Sanderlings were found on sandy beaches to the west of Panama City, especially on the sandy beaches near Punta Chame (Sector 65, 140 birds, 61.2% of total) and along the coastline to the north of the Bahia de Parita in Sector 68 (60 birds, 26.8% of total). The same parts of the coast were important for Sanderlings in October 1991, with highest numbers being seen on the sandy beaches north of Punta Chame to the west of Panama City in Sector 64 (200 birds, 58.3% of gulf total).

## 5.3 Medium-sized shorebirds

### 5.3.1 Overall distribution

5.3.1.1 Pacific and Caribbean coasts, January 1993

*Maps 5.5–5.9; Tables 5.2, 5.4*

A total of 12 300 medium-sized shorebirds (4.8% of all shorebirds) was counted on the surveys in January 1993. It was not always possible to distinguish between medium-sized species from the air, especially as they were often encountered among large concentrations of other small and/or large shorebirds, resulting in 8500 (69.1% of the medium-sized total) being assigned to a general "unidentified medium-sized shorebird" category. Dowitchers (mostly Short-billed Dowitchers *Limnodromus griseus*) were the most numerous species category (3100, 25.1% of the medium-sized total), and it is likely that many of the unidentified medium-sized shorebirds were this species.

The vast majority of medium-sized species were observed on the Pacific coast (12 100, 98.6%). Only small numbers were seen on the Caribbean coast (170, 1.4%), most of them in the Laguna de Chiriqui (Sectors 14–17) in the northwest, with some birds along the shores of the Golfo de los Mosquitos (Sectors 18–30) and north-central coast (Sectors 31–35): none was seen in the eastern part of the north coast (Sectors 36–50). On the Pacific coast, the Golfo de Panama (Sectors 55–71) was the most important region for this category, supporting 10 700, or 87.5%, of the Panamanian total. The highest numbers of medium-sized shorebirds were seen in the mud pans, salt pans, and shrimp ponds behind the Bahia de Parita (Sectors 69 and 70, 6300, 58.9% of the Golfo de Panama total). Important concentrations were also found on the intertidal flats to the east (Sectors 61 and 62) and west (Sectors 64 and 65) of Panama City, as well as in the bays north of Garachine (Sectors 55–57). Moderate concentrations were found in the Golfo de Montijo (Sectors 84–88) and in the inlets and on the beaches of the Golfo de Chiriqui (Sectors 92–107) in western Panama. The overall distribution was less clumped than that found for the "peeps," probably owing to somewhat different habitat preferences shown by the different species (see below).

5.3.1.2 Golfo de Panama, February 1988 and October 1991

*Tables 5.6, 5.8*

The total of all medium-sized shorebirds in the Golfo de Panama during the wintering period surveys in January 1993 (10 700) was similar to that counted during the migration period survey in February 1988 (9400), with the largest numbers being observed during the period of southward migration in October 1991 (13 100). The most important area during both migration periods was the mudflats east of Panama City (Sectors 61 and 62), which held 8200 and 3700 medium-sized shorebirds during the October and February surveys, respectively (62.6% and 39.0% of the gulf totals, respectively). The mud pans and salt pans in the Bahia de Parita (Sectors 69 and 70) were not as proportionally important according to survey results in October and February, although they still held significant numbers of shorebirds

(1900 [14.6%] and 1300 [14.2%], respectively). The bays of the Golfo de San Miguel near Garachine in the eastern part of the Golfo de Panama (Sectors 55–57) held notable numbers of medium-sized shorebirds in February 1988 (2300, 24.2% of the gulf total). The other area that consistently appeared to support concentrations of medium-sized birds was the flats in Bahia de Chame and to the west of Panama City (Sectors 64 and 65).

### 5.3.2 Black-bellied Plover *Pluvialis squatarola*

#### 5.3.2.1 Pacific and Caribbean coasts, January 1993

*Map 5.6; Table 5.4*

A modest total of 440 Black-bellied Plovers was distributed fairly widely around the coast of Panama, with 72 (16.3%) on the Caribbean coast and 370 (83.7%) on the Pacific coast. On the north coast, the most important concentrations occurred in the Laguna de Chiriqui (48, 10.9% of the Panamanian total, 66.7% of the north coast total), with smaller numbers along the north-central coast between Colon and El Porvenir. On the Pacific coast, the major concentration occurred on the flats east of Panama City, where 170 (37.3% of the Panamanian total) were counted in Sectors 61 and 62. Moderate numbers were found in the inlets off the Golfo de Chiriqui in western Panama (Sectors 100 and 104) and in Bahia de Parita (Sector 70).

#### 5.3.2.2 Golfo de Panama, February 1988 and October 1991

*Table 5.8*

Considerably more Black-bellied Plovers were counted during southward migration in October 1991 (1160) in the Golfo de Panama than during surveys in February 1988 (490) or January 1993 (210). The highest numbers recorded on the October and February surveys occurred in the Bahia de Parita (Sectors 69 and 70, 480 [41.7% of the gulf total] and 230 [47.6% of the gulf total] in October 1991 and February 1988, respectively). In October 1991, numbers were fairly equal east (610, 52.4%) and west (550, 47.6%) of Panama City, with the flats east of Panama City (Sectors 61 and 62, 230, 19.7%; Sectors 59 and 60, 180, 15.2%) and bays of the Golfo de San Miguel (Sectors 55–57, 200, 17.4%) holding notable numbers. In February 1988, most Black-bellied Plovers were found west of Panama City (440, 89.8%), with the coastline between Bahia de Chame and Panama City holding a further 200 (40.0%) birds in addition to those in the Bahia de Parita. Intertidal flats in these areas appeared generally to contain firmer and/or sandier substrates than those found in the extensive flats east of Panama City and towards Garachine, suggesting a preference for such habitats. Many of the Black-bellied Plovers that did occur on the flats east of Panama City tended to occur in areas of firmer substrates.

### 5.3.3 Killdeer *Charadrius vociferus*

*Table 5.8*

This species was not observed during surveys in January 1993 or October 1991. One bird was observed during the surveys in February 1988 on the shores of Bahia de Parita. Ridgely and Gwynne (1989) listed the Killdeer as an uncommon to fairly common transient and winter resident. Delgado and Butler (1993) reported only a few (7) from ground surveys conducted in Bahia de Parita, the species being seen only in January (surveys conducted September–March). The aerial surveys did not cover habitat specifically suitable for this relatively uncommon species.

### 5.3.4 Yellowlegs: Greater Yellowlegs *Tringa melanoleuca* and Lesser Yellowlegs *T. flavipes*

#### 5.3.4.1 Pacific and Caribbean coasts, January 1993

*Map 5.7; Table 5.4*

The only yellowlegs (total 4) seen on the surveys in January 1993 occurred on the west side of the Bahia de Panama, in the ponds behind the shoreline in the Bahia de Parita (Sector 70, 2) and along the shoreline north of the Bahia de Parita (Sectors 67 and 68, 1 each). Ridgely and Gwynne (1989) described both species of yellowlegs as uncommon winter residents.

#### 5.3.4.2 Golfo de Panama, February 1988 and October 1991

*Table 5.8*

Rather few yellowlegs (total 6) were observed in the Golfo de Panama in October 1991, all but one being seen in the ponds behind the shoreline of Bahia de Parita.

Yellowlegs were much more common on the surveys in February 1988, with a total of 250 being seen around the Golfo de Panama. Yellowlegs were identified most frequently around Bahia de Parita (Sectors 69 and 70, 99, 40.1%; Sector 71 running south of Bahia de Parita, 27, 10.9%), on the flats east and west of Panama City (Sectors 61 and 62, 42, 17.0%, and Sector 64, 52, 21.1%, respectively), and in the inner parts of the bays in the eastern parts of the Golfo de Panama (Sector 57, Golfo de San Miguel, 24, 9.7%). Many of the yellowlegs around the Bahia de Parita were found on open muddy areas and salt pans occurring behind the coastal mangrove fringe. Delgado and Butler (1993) reported that both Greater and Lesser yellowlegs occurred in this area, Greater Yellowlegs being the most numerous. The present survey results are consistent with the observations of Delgado and Butler (1993), in that yellowlegs were found to be most numerous in Bahia de Parita during February, with lower numbers during southward migration in the fall (September/October). Ridgely and Gwynne (1989), on the other hand, described both species as fairly common (Lesser Yellowlegs) or common (Greater Yellowlegs) transients, especially during the fall.

### 5.3.5 Ruddy Turnstone *Arenaria interpres*

#### 5.3.5.1 Pacific and Caribbean coasts, January 1993

*Map 5.8; Table 5.4*

Ruddy Turnstones were not especially numerous (total 270) but were widely distributed around the coast of Panama, occurring on both Caribbean (66, 24.4%) and Pacific (210, 75.6%) coasts.

Most of the birds on the Caribbean side were found in the inner parts of the Laguna de Chiriqui on sandy beaches with scattered tide wrack (Sector 16, 58, 87.9% of the Caribbean total, 21.4% of the Panamanian total), with smaller numbers distributed along coasts with beaches and rocky points.

On the Pacific coast, turnstones preferred shorelines with sandy or gravelly beaches or firm muddy substrates. The highest concentrations were noted on the west side of the Golfo de Montijo (Sectors 87 [Isla Leone] and 88,

110 birds, 53.7% of the Pacific total) and in the west of the country along the sandy shores of Isla Sevilla (Sector 102, 30, 14.6% of the Pacific total). Moderate concentrations were also found along shores with firm muddy substrates in the eastern parts of the Golfo de Panama (Sectors 56, 59, and 61).

5.3.5.2 Golfo de Panama, February 1988 and October 1991

*Table 5.8*

Numbers of turnstones in the Golfo de Panama were considerably greater during the migration period surveys in February 1988 (580) and October 1991 (150) than during the winter surveys in January 1993 (50). The majority were seen in the eastern half of the gulf (490 [85.1%] in February 1988, 140 [95.2%] in October 1991), with the birds again appearing to favour areas with firm intertidal substrates. In February 1988, highest numbers were found in Sectors 61 and 62 east of Panama City (390, 67.4%) and around the Golfo de San Miguel in Sectors 55–57, where rocky habitats occur near the town of Garachine. Significant numbers were also found in the ponds and salt pans bordering Bahia de Parita (Sectors 69 and 70, 86, 14.9%) in the west of the gulf. In October 1991, the same coastal sectors were important for turnstones in the eastern half of the gulf, although the majority occurred in the Golfo de San Miguel (100, 70.5%) rather than east of Panama City (32, 21.9%). No turnstones were observed in the far west of the gulf in Bahia de Parita.

These results are consistent with those of Delgado and Butler (1993) and Schneider and Mallory (1982), who noted highest numbers of turnstones during February at sites in Bahia de Parita and near Panama City, respectively.

### 5.3.6 Dowitchers: Short-billed Dowitcher *Limnodromus griseus* and Long-billed Dowitcher *L. scolopaceus*

The majority of the dowitchers occurring in the area are thought to be Short-billed Dowitchers (Ridgely and Gwynne 1989; Delgado and Butler 1993).

5.3.6.1 Pacific and Caribbean coasts, January 1993

*Map 5.9; Table 5.4*

Dowitchers (total 3100) were the most numerous of the medium-sized shorebirds, making up 25.1% of the birds in this category (81.1% of the identified medium-sized species). Interpretation of dowitcher distribution is complicated by the fact that a high proportion (69.1%) of the medium-sized shorebird total consisted of unidentified species. It appears likely that many of the unidentified medium-sized shorebirds recorded on the surveys will have been dowitchers: many unidentified birds in this category were found in flocks in habitats typically used by dowitchers (mudflats). Flock characteristics were typical of dowitchers and were not likely to be confused with other species in the medium-sized category (e.g., Black-bellied Plover, Ruddy Turnstone, which occurred overall in much lower numbers).

All of the total of 3100 identified dowitchers occurred on the Pacific coast, most (2800, 89.6%) being found within the Golfo de Panama. Highest numbers were found in the salt pans and muddy ponds behind the shoreline of Bahia de Parita (Sectors 69 and 70, 1900, 62.0%). Other concentrations were found on the flats east of Panama City (Sector 62, 400, 13.0%) and in the east of the gulf near Garachine (Sector 55, 100, 3.3%). Dowitchers were numerous in areas with extensive intertidal flats, and it is likely that they are much more widely distributed around the (northern) Golfo de Panama than is indicated in Map 5.9. Assuming that many of the unidentified medium-sized shorebirds were dowitchers, a more representative interpretation of dowitcher distribution will be obtained by considering a combination of the counts of identified dowitchers and unidentified medium-sized shorebirds. This indicates that dowitchers are numerous in all areas in the upper gulf containing extensive mudflats, from east of Panama City to Punta Chame (Sectors 59–66), around the eastern Golfo de San Miguel (Sectors 55 and 56), and in Bahia de Parita (Sectors 69 and 70).

Outside of the Golfo de Panama, dowitchers were identified in moderate concentrations in the Golfo de Montijo (Sectors 84, 320, 10.4% of the identified total). Although not specifically identified, they are also likely to occur in some of the inlets with intertidal flats in the west of the country bordering the Golfo de Chiriqui, as indicated by flocks of unidentified medium-sized shorebirds (e.g., Sector 103, Boca de San Pedro estuary, 470).

5.3.6.2 Golfo de Panama, February 1988 and October 1991

*Table 5.8*

Comparison of dowitcher distribution in the three sets of surveys is complicated by the varying proportion of unidentified medium-sized shorebirds counted on each occasion; this ranged from 17.4% of the medium-sized shorebird total in October 1991, through 46.8% in February 1988, to 71.9% in January 1993. Interpretation of dowitcher distribution is thus most straightforward for the October 1991 surveys, as the proportion of unidentified medium-sized species is low and the numbers of identified dowitchers high (9500, comprising 72.6% of the overall medium-sized total and 87.9% of the total of identified medium-sized species). The most important areas were clearly the coastal sectors to the east of Panama City (Sectors 61 and 62), which held 7700 (81.3%) of the identified dowitchers, as well as the flats and salt and mud pans around Bahia de Parita (Sectors 69 and 70, 1200, 12.9%). Areas in the east of the Golfo de Panama around the Golfo de San Miguel were also important, assuming that many of the unidentified medium-sized shorebirds were dowitchers.

The higher proportion of unidentified medium-sized shorebirds in the February 1988 surveys makes interpretation of dowitcher distribution somewhat less straightforward, although examination of identified and unidentified counts indicates again that the key areas were found east of Panama City, in the Golfo de San Miguel, around Bahia de Parita, and also in the sectors west of Panama City to Bahia de Chame.

## 5.4 Large shorebirds

### 5.4.1 Overall distribution

5.4.1.1 Pacific and Caribbean coasts, January 1993

*Maps 5.10–5.14; Tables 5.2, 5.5, 5.6*

A total of 6200 large shorebirds was counted on the surveys in January 1993, most (6100, 97.7%) of which were

found on the Pacific coast. The Golfo de Panama (Sectors 55–71) was the most important region, harbouring 5000, or 83.0% of the Pacific coast total, with large concentrations found on the flats to the east of Panama City (Sectors 61 and 62, 2300, 38.5% of the Pacific coast total), in the bays of the Golfo de San Miguel, especially near Garachine (Sectors 55–57, 1400, 22.2%), along the coastline between these two areas (Sectors 58–60, 740, 12.2%), and in the Bahia de Parita (Sectors 69 and 70, 530, 8.7%). Large shorebirds were widely distributed along most of the remainder of the Pacific coastline, with concentrations in the Golfo de Montijo (Sectors 84–88, 770, 12.7%) and in some of the inlets facing the Golfo de Chiriqui in the west of the country.

On the Caribbean side, 130 (93.0%) of the 140 large shorebirds were observed along the mangrove and sandy shorelines of the Laguna de Chiriqui in the northwest, with smaller numbers scattered along the central parts of the coast to the east of Colon.

All but 55 (0.9%) of the total of 6200 large shorebirds were identified to species. Most large species could be identified from the air regularly, not only by virtue of their size but because of their distinctive appearances. The two most common species were the Willet (4400, 70.0% of the large total) and Whimbrel (1600, 25.3% of the large total), which together made up 95.3% of the large category total.

5.4.1.2 Golfo de Panama, February 1988 and October 1991
*Tables 5.6, 5.9*

Large shorebirds were considerably more numerous in the Golfo de Panama during migration periods than during the wintering period, with totals of 26 700 in October 1991 and 15 200 in February 1988, compared with 5000 in January 1993. Large species also outnumbered medium-sized species during the migration periods, the situation being reversed from that observed during the winter period. The extensive mudflats and mangrove coastlines in the eastern half of the gulf between Panama City and Garachine (Sectors 55–62) were of great importance for large species, holding 90.9% (13 800), 91.0% (24 300), and 87.9% (4400) of the gulf totals in February 1988, October 1991, and January 1993, respectively. The area of greatest importance was the flats to the east of Panama City (Sectors 61 and 62), which held 6820 (56.7% of the gulf total) and 18 200 (68.1% of the gulf total) large shorebirds in February 1988 and October 1991, respectively. Other consistently important areas included the eastern bays of the Golfo de San Miguel around Garachine (Sectors 55–57, 3400 [22.6% of the gulf total] in February 1988 and 2200 [8.3% of the gulf total] in October 1991), and the remaining coastline towards Panama City (Sectors 58–60, 1800 [11.6% of the total] and 3900 [14.6% of the total] in February 1988 and October 1991, respectively). The most heavily used areas in the western half of the Golfo de Panama were the flats and adjacent muddy habitats of the Bahia de Parita (Sectors 69 and 70, 580 [3.8%] and 1400 [5.3%] in February 1988 and October 1991, respectively) and the flats between Punta Chame and Panama City (Sectors 64 and 65, 750 [4.9%] and 890 [3.3%] in February 1988 and October 1991, respectively).

### 5.4.2 American Oystercatcher *Haematopus palliatus*

5.4.2.1 Pacific and Caribbean coasts, January 1993
*Map 5.11; Table 5.5*

All of the total of some 150 American Oystercatchers were observed on the Pacific coast. The species was most numerous in areas with sand beaches and nearby intertidal flats, such as those found in Bahia de Chame (Sector 65, 45, 29.4% of the total), east of Panama City (Sector 61, 40, 26.1% of the total), and in Bahia de Parita (Sectors 69 and 70, 39, 25.5% of the total). Smaller numbers were observed in the west of the country on the beaches near inlets around the Golfo de Chiriqui and Golfo de Montijo.

5.4.2.2 Golfo de Panama, February 1988 and October 1991
*Table 5.9*

Totals were again moderate to low on the migration period surveys, being somewhat lower than the winter total in February 1988 (67 birds) and higher in October 1991 (250). Areas with sandy beaches and nearby intertidal flats or muddy areas were again favoured, especially east of Panama City and in Bahia de Parita.

### 5.4.3 Black-necked Stilt *Himantopus mexicanus*

5.4.3.1 Pacific and Caribbean coasts, January 1993
*Map 5.12; Table 5.5*

Ridgely and Gwynne (1989) described the Black-necked Stilt as "uncommon, local and apparently somewhat erratic on mudflats and fresh water ponds and marshes on both coasts (more numerous on Pacific)." This description is consistent with the results of the surveys, except that stilts were observed only on the Pacific coast during the January 1993 flights. All observations of stilts occurred around the coastline of the Golfo de Panama. In January 1993, all but one of the total of 86 stilts were found on the muddy, flooded areas adjacent to the Bahia de Parita, the single other bird being observed on the coast east of Panama City in Sector 61.

5.4.3.2 Golfo de Panama, February 1988 and October 1991
*Table 5.9*

In February 1988, the situation was the opposite of that observed in January 1993, with 80 of the 81 birds being found in Sector 61 and the remaining single bird being found in the salt/mud pans behind the shoreline in Bahia de Parita. Black-necked Stilts were most numerous on the October 1991 surveys and were found in the same areas: 168 of the total of 169 birds were found east of Panama City (Sectors 61 and 62), with the single remaining bird again in the salt/mud pans adjacent to Bahia de Parita. The species was not reported by Delgado and Butler (1993) during ground counts of the latter area between September 1990 and March 1991.

### 5.4.4 Marbled Godwit *Limosa fedoa*

*Table 5.9*

Marbled Godwits were observed only on the surveys conducted in October 1991, when a total of 700 was counted in the eastern half of the Golfo de Panama. Most occurred on the extensive mudflats found in the three sectors to the east of Panama City (Sectors 60–62, 650, 92.6%);

smaller numbers were found in the Ensenada de Garachine (Sector 55, 50, 7.1%).

Ridgely and Gwynne (1989) stated that the Marbled Godwit is a regular transient and summer and winter visitant to the vast flats of Panama Viejo at the east end of the city. They suggested that the species might be most abundant during spring migration (based on sightings at Panama Viejo), although Schneider and Mallory (1982) did not record the species during winter and spring counts at three sites near the southern entrance to the Panama Canal near Panama City. In the western part of the Golfo de Panama, Delgado and Butler (1993) noted that Marbled Godwits were sporadic in occurrence in Bahia de Parita; they were recorded in small numbers in counts made in October, December, January, and March, with largest numbers occurring in October. The present survey data and counts made by Delgado and Butler (1993) suggest that Marbled Godwits are, in fact, most abundant in Panama during southward migration in October.

### 5.4.5 Willet *Catoptrophorus semipalmatus*

#### 5.4.5.1 Pacific and Caribbean coasts, January 1993

*Map 5.13; Table 5.5*

The Willet was the most numerous large shorebird seen during the surveys in January 1993, the total of 4400 comprising 70.0% of this size class. Willets occurred on both coasts but were much more common on the Pacific (4300, 98.7% of the total) than on the Caribbean (55, 1.3% of the total) side.

Most (51, 92.7% of the Caribbean total) of the Willets on the Caribbean coast were found on the mangrove and sandy coasts of the mainland portion of the Laguna de Chiriqui in the northwest (Sectors 14–16), the remaining four birds being observed in Sector 34 near El Porvenir.

Willets were widely distributed on the Pacific coast. Highest concentrations occurred around the Golfo de Panama, which held 86.7% (3700) of the Pacific coast total, and appeared to be associated with areas of firm intertidal flats backed by mangroves. Within the Golfo de Panama, the most important habitats were found east of Panama City (Sectors 61 and 62, 1800, 41.7% of the Pacific coast total), around Golfo de San Miguel, especially near Garachine (Sectors 55–57, 1100, 25.8%), and along the coast between these areas (Sectors 58–60, 520, 12.1%); in the western part of the gulf, the highest numbers were found in the salt/mud pans associated with Bahia de Parita (Sectors 69 and 70, 280, 6.5%). The most important area outside the Golfo de Panama was the Golfo de Montijo (Sectors 84–88), which held 430 birds (10.0% of the Pacific coast total); smaller numbers were found in the inlets and along the beaches facing the Golfo de Chiriqui in the west of the country.

#### 5.4.5.2 Golfo de Panama, February 1988 and October 1991

*Table 5.9*

Willets were considerably more numerous during the spring and fall migration periods than during the wintering period, with totals in the Golfo de Panama of 11 000 in February 1988 and 13 600 in October 1991, compared with 3700 in January 1993. Areas with extensive intertidal areas and mangroves were again of greatest importance, with the sectors east of Panama City (Sectors 61 and 62) holding the highest numbers of Willets on both February 1988 (7000, 63.9% of the gulf total) and October 1991 (9800, 72.1% of the gulf total) surveys. Sectors in the Golfo de San Miguel, especially around Garachine (Sectors 55–57), held substantial numbers on both surveys (2500, 22.7% of the February 1988 total; 940, 6.9% of the October 1991 total). In the western Golfo de Panama, moderate numbers were found in the salt/mud pans and along the shoreline of the Bahia de Parita (Sectors 69 and 70, 200, 1.8% of the February 1988 total; 970, 7.1% of the October 1991 total).

### 5.4.6 Whimbrel *Numenius phaeopus*

#### 5.4.6.1 Pacific and Caribbean coasts, January 1993

*Map 5.14; Table 5.5*

The Whimbrel was the second most numerous large shorebird counted on the surveys in January 1993, with a total of 1600 birds. The species was distributed widely and occurred on both coasts, although numbers were much higher on the Pacific side (1500, 94.4% of the survey total) compared with the Caribbean coast (88, 5.6% of the survey total).

On the Caribbean side, most birds were found along the mangrove coasts of the Laguna de Chiriqui in the northwest (Sector 14), where 93.2% (82 birds) of the Caribbean total occurred. Smaller numbers were scattered along the beaches and mangrove shores of the north-central coast.

The Whimbrel was widely distributed on the Pacific coast, occurring most commonly in areas with intertidal flats backed by mangroves, although it was also found along coasts with sand and gravel beaches. The most important areas were found in the Golfo de Panama, which held 70.5% (1000) of the Pacific coast total: the highest concentrations were found east of Panama City (500, 33.9% of the Pacific coast total) and towards Garachine in the east in the Golfo de San Miguel (240, 16.2%). In the western gulf, moderate numbers were found around the shorelines of the Bahia de Parita (Sectors 69 and 70, 120, 7.9%). The largest concentrations outside the Golfo de Panama were found on the mangrove-lined shores of the Golfo de Montijo (Sectors 84–88), which supported a further 340 (22.7%) birds. Smaller numbers of Whimbrels were found on both the ocean beaches and inlets facing the shore of the Golfo de Chiriqui in the west of the country (Sectors 92–107) and on the south coast of the Peninsula de Azuero (Sectors 75–80).

#### 5.4.6.2 Golfo de Panama, February 1988 and October 1991

*Table 5.9*

Whimbrels were considerably more numerous during the migration period surveys, with Golfo de Panama totals of 4100 in February 1988 and 5300 in October 1991, compared with 1000 in January 1993. Habitats in the eastern half of the Golfo de Panama between Panama City and Garachine (Sectors 55–62) supported a high percentage of the birds in all three seasons: 84.5% (3400), 85.0% (4500), and 88.4% (930) in February 1988, October 1991, and January 1993, respectively. The centre of distribution was to the east of Panama City. In addition to substantial numbers being found on the extensive flats in the northern Golfo de Panama (Bahia de Panama) in the two sectors east of Panama City (Sectors 61 and 62; 1500 [36.5% of the gulf total], 1900 [35.7%], and 500 [48.1%] in February 1988, October 1991, and January 1993, respectively), the adjacent sectors to the

east (Sectors 58–60), especially Sector 60, also supported large numbers, particularly during southward migration (1000 [25.0%], 2000 [38.1%], and 180 [17.3%] in February 1988, October 1991, and January 1993, respectively). The bays of Golfo de San Miguel (Sectors 55–57), especially the Ensenada de Garachine (Sector 55), also held significant numbers (940 [23.0%], 590 [11.2%], and 240 [23.0%] in February 1988, October 1991, and January 1993, respectively). In the western half of the Golfo de Panama, the most important concentrations of Whimbrels were found using the flats and associated salt/mud pans of Bahia de Parita (Sectors 69 and 70, 370 [9.1%], 430 [8.2%], and 120 [11.2%] in February 1988, October 1991, and January 1993, respectively). The Bahia de Chame (Sector 65) also supported significant numbers of Whimbrels during the migration periods (220 [5.3%] and 300 [5.7%] in February 1988 and October 1991, respectively, vs. 1 [0.1%] in January 1993).

## 5.5 Discussion

A number of conclusions emerge clearly from the series of aerial surveys conducted in January 1993, October 1991, and February 1988: (1) the coast of Panama contains areas of international importance for shorebirds, the most significant of which are found in the northern parts of the Golfo de Panama; (2) the highest numbers and densities of shorebirds occur on mudflats, particularly where the mudflats are associated with mangrove forests and/or where suitable roosting beaches are also found: highest densities occurred on the Pacific coast in areas influenced by oceanic upwelling around the Golfo de Panama (see Chapter 7); (3) the greatest numbers and densities of shorebirds occur on the Pacific coast, with much lower numbers occurring on the Caribbean side; and (4) the highest counts of many species of shorebirds in the Golfo de Panama were recorded during surveys in October 1991, suggesting highest numbers may occur during southward migration (see below).

The presence of highly productive habitats suitable for shorebirds in the northern Golfo de Panama has resulted from a combination of geomorphological processes and oceanographic conditions. Extensive sediment deposition occurs in the northern parts of the gulf (Bahia de Panama), particularly to the east of Panama City, as well as in the inlets in the eastern part of the Golfo de Panama around the Golfo de San Miguel, in Bahia de Chame, and in Bahia de Parita, where large areas of open mud pans occur behind the outer shoreline. Most of the sediments making up the mudflats and sandflats in these areas appear to be derived from local rivers. Although not a lot of information is available on the invertebrate populations inhabiting these intertidal flats (J. Christy, pers. commun.), it seems likely that the areas will be highly productive in terms of the food resources used by shorebirds (and other waterbirds). Nutrient input not only will occur from local rivers but is likely to be enhanced through the pronounced upwelling that occurs in the Golfo de Panama during the dry season from around mid-December/January to mid-April (Chapter 3). This upwelling, which is a local phenomenon produced by the northeasterly trade wind system, is also accompanied by a drop in ocean temperature of around 3–4°C (Glynn 1977). Neither the upwelling nor the drop in ocean temperature is found in the Golfo de Chiriqui in the west of the country, so there is likely to be less nutrient input from the ocean into intertidal areas in the latter region. Many of the intertidal flats in the west of the country are found in sheltered inlets or estuaries, in contrast to those surrounding the Golfo de Panama, which are found along open or much less sheltered coastlines. Furthermore, the key areas for shorebirds in the northern Golfo de Panama also contain suitable roosting habitats near intertidal areas used for feeding. Suitable roosting habitats include sandy beaches or firm muddy or sandy areas that remain uncovered by water at high tide; in Bahia de Parita, many shorebirds use the open mud and salt pans found behind the outer shoreline for roosting when the intertidal flats on which they feed are covered by the tide. Fewer suitable roosting sites were noted during surveys of the estuaries and inlets around the Golfo de Chiriqui; in many cases, water flooded right up to and into the shoreline mangroves or other vegetation at high tide in these locations (although coastal beaches and/or sandbars were located along the outer shoreline). Linear densities of shorebirds are much higher in the key areas around the Golfo de Panama compared with the estuaries and inlets around the Golfo de Chiriqui (Appendices 1–3), presumably as a result of a combination of the factors noted above (see also Chapter 7).

Numbers and densities of shorebirds were also much higher on the Pacific coast than on the Caribbean coast. Tidal amplitudes were considerably lower on the Caribbean side (approx. 1 m vs. 5 m on the Pacific coast), and the amount of intertidal habitat is also considerably less. Few muddy intertidal areas were noted on the surveys: in the northwest, small amounts occurred in the Laguna de Chiriqui, and some muddy zones were found in the islands along the eastern sectors of the north coast beyond the Archipielago de San Blas, although no shorebirds were noted on the latter. Oceanographic differences are also evident: no upwelling or coastal currents likely to elevate nutrient input are present along the Caribbean side. The most prevalent intertidal habitat on the north coast consisted of wave-washed coral platforms: these were utilized to a moderate degree by wading birds, but few shorebirds were found on them, and it is possible that potential food items were of the wrong size or type for shorebirds.

For most species of shorebirds, maximum numbers in the Golfo de Panama were recorded on the surveys in October 1991 (counts ranging from two to five times those recorded on the lowest survey count). Survey conditions can influence numbers of birds counted, especially tide height and weather (as shown by coverage of the same sectors at different tide heights on the same day; RIGM, RKR, FSD, unpubl. data). Counts, however, were available for all the surveys in the Golfo de Panama when the tide was high, and weather conditions were similar enough between surveys not to have been considered an influential factor affecting results. The limited number of shorebird studies available from the Pacific coasts of Panama and Costa Rica (Smith and Stiles 1979; Schneider and Mallory 1982; Delgado and Butler 1993) indicate that a passage of migrant shorebirds of various species occurs through Central America during both autumn and spring periods. In Costa Rica, Smith and Stiles (1979) found that peak numbers of many species occurred in autumn (September, October, November), whereas Delgado and Butler (1993) found that maximum counts of many shorebirds near Chitre on Bahia de Parita peaked during spring migration, which they considered to occur principally in February (see also Schneider and Mallory 1982). The

present aerial surveys were thus conducted roughly during peak periods of autumn migration (October 1991), winter (January 1993), and spring migration (February 1988). Considering variation in the phenology of migration for different species and the length of time over which the migration passage may last, however, the correspondence can be considered only very approximate. Nevertheless, the survey results are strongly suggestive that highest numbers of shorebirds occur during southward migration in the autumn, when many species will pass through the area to wintering grounds farther south in South America (Morrison and Ross 1989). Maximum population sizes for many species will also occur during the fall, owing to the presence in the population both of adults and of juveniles hatched the previous summer. It appears that spring migration in Costa Rica is more rapid and compressed than fall migration, at least for the smaller species (Smith and Stiles 1979); there is therefore considerable uncertainty whether the February surveys, conducted over a period of two days in 1988, will have occurred during the peak period of migration.

The results emphasize the importance of the coast of Panama not only to wintering populations of shorebirds but also to migrants passing through the area. Maximum counts of shorebirds in the Golfo de Panama of over 369 000 in October 1991 indicate that the area would qualify directly as a site of International importance under the criteria of the Western Hemisphere Shorebird Reserve Network (WHSRN) (Morrison et al. 1995); when turnover of individual birds moving through the area in both spring and autumn migration periods is considered, it would appear that the total number of birds using the area is very likely to exceed 500 000, which would qualify the area as a WHSRN Hemispheric site. These numbers also far exceed the criteria for identification of the region as a wetland of international importance (20 000 birds) under the Ramsar Convention (Rose and Scott 1994), indicating that the area would also be a suitable candidate for future nomination as a Ramsar site.

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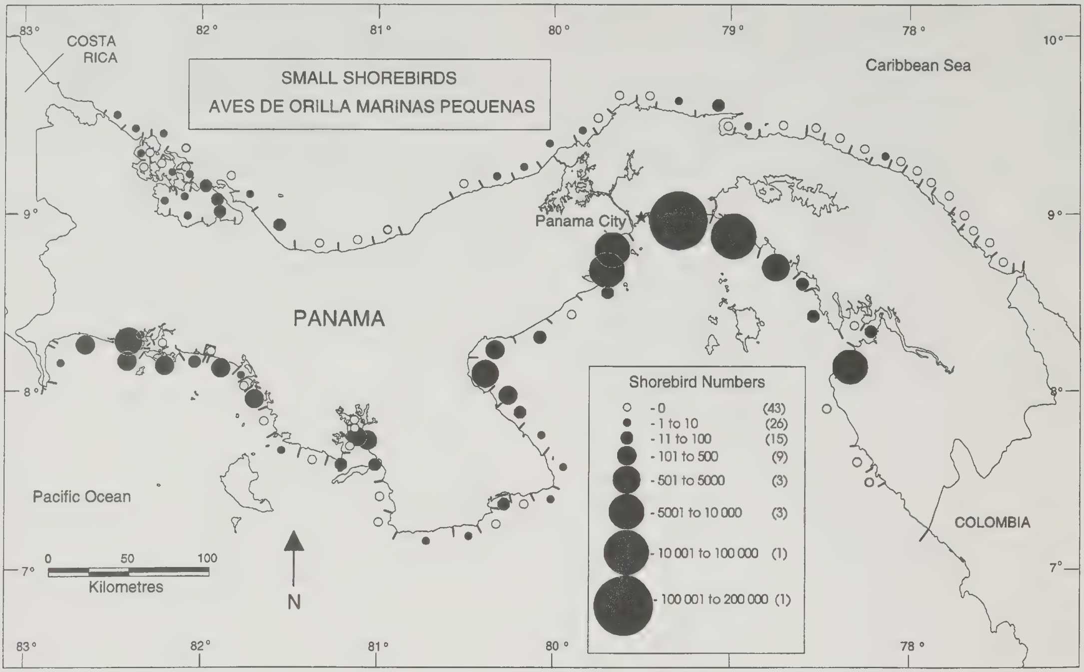
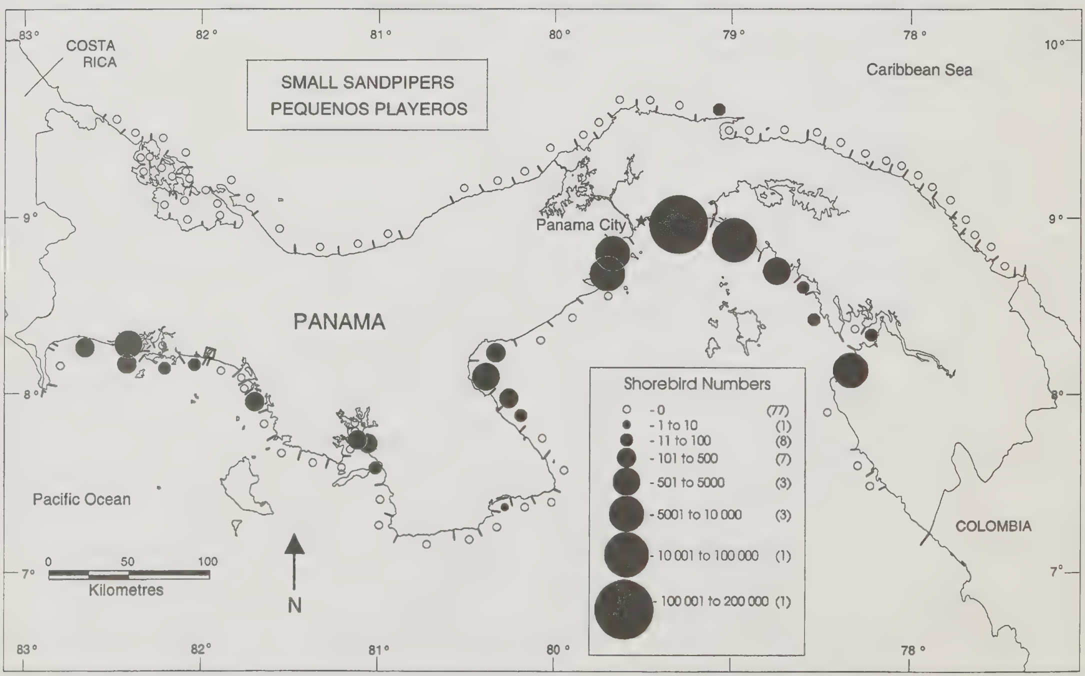
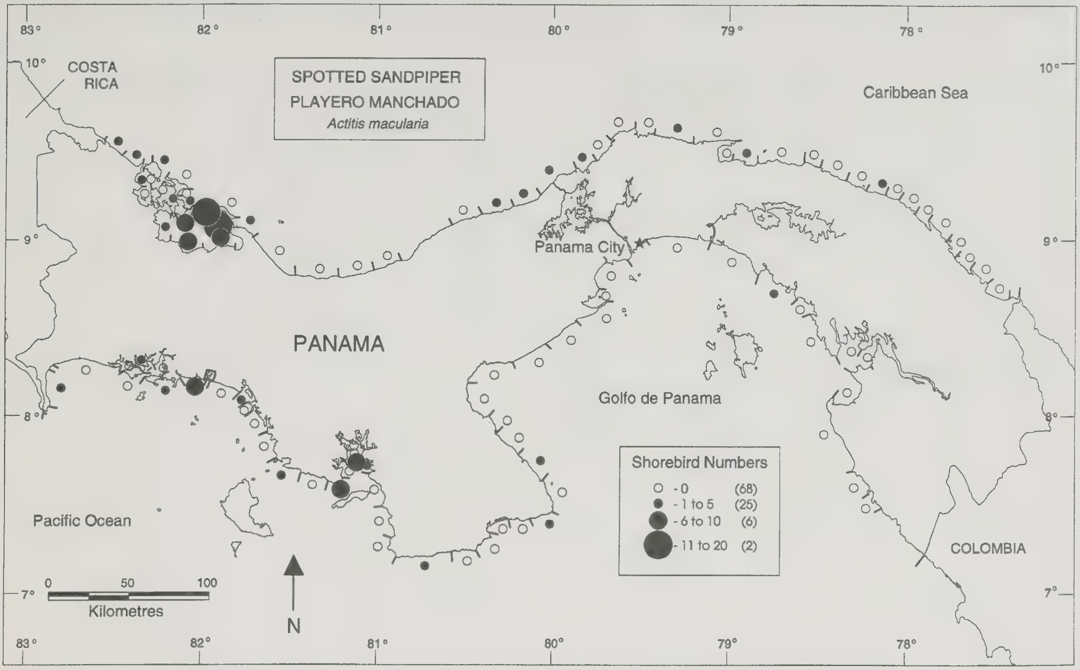
**Map 5.1**
Distribution of small shorebirds on the coast of Panama during aerial surveys in January 1993



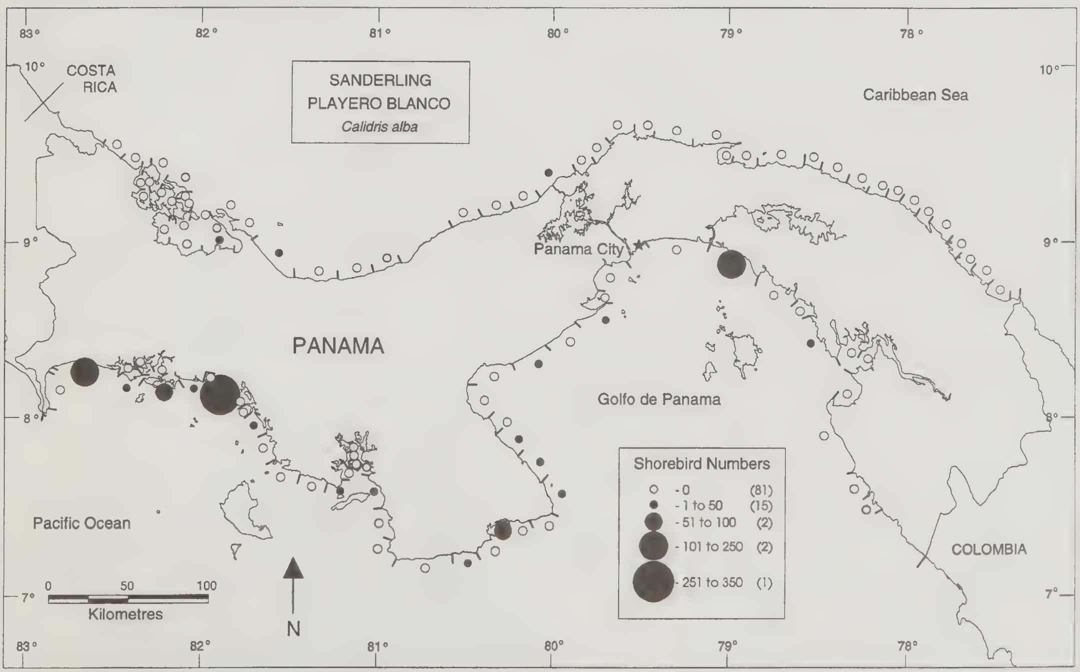

**Map 5.2**
Distribution of unidentified small sandpipers (mostly Western Sandpipers *Calidris mauri*) on the coast of Panama during aerial surveys in January 1993



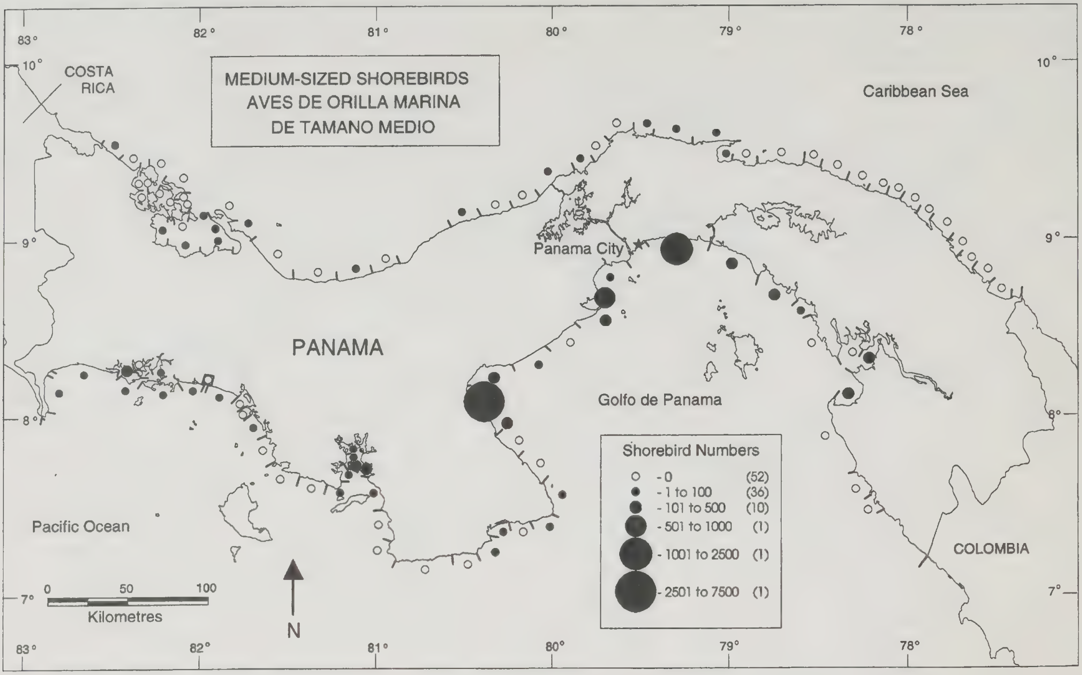
**Map 5.3**
Distribution of Spotted Sandpipers *Actitis macularia* on the coast of Panama during aerial surveys in January 1993



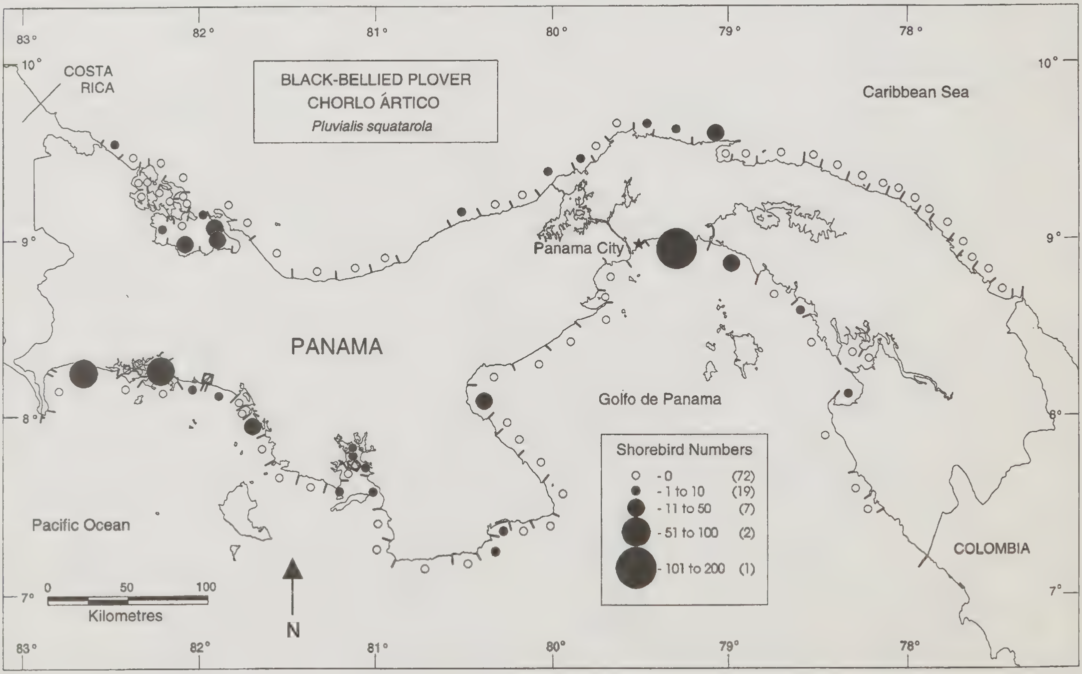

**Map 5.4**
Distribution of Sanderlings *Calidris alba* on the coast of Panama during aerial surveys in January 1993



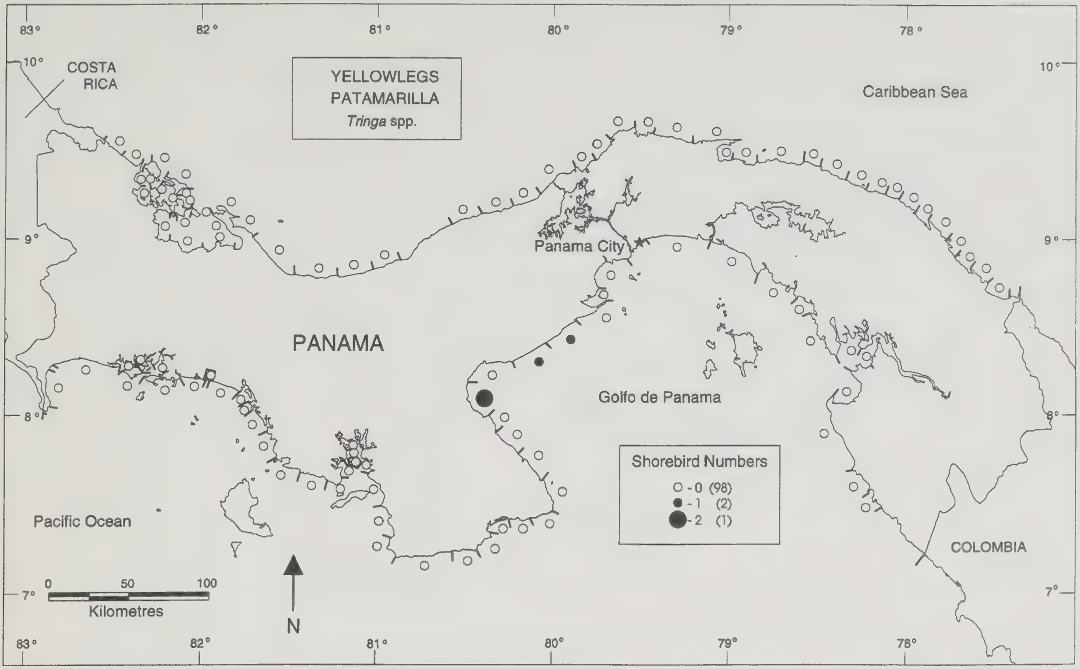
**Map 5.5**
Distribution of medium-sized shorebirds on the coast of Panama during aerial surveys in January 1993



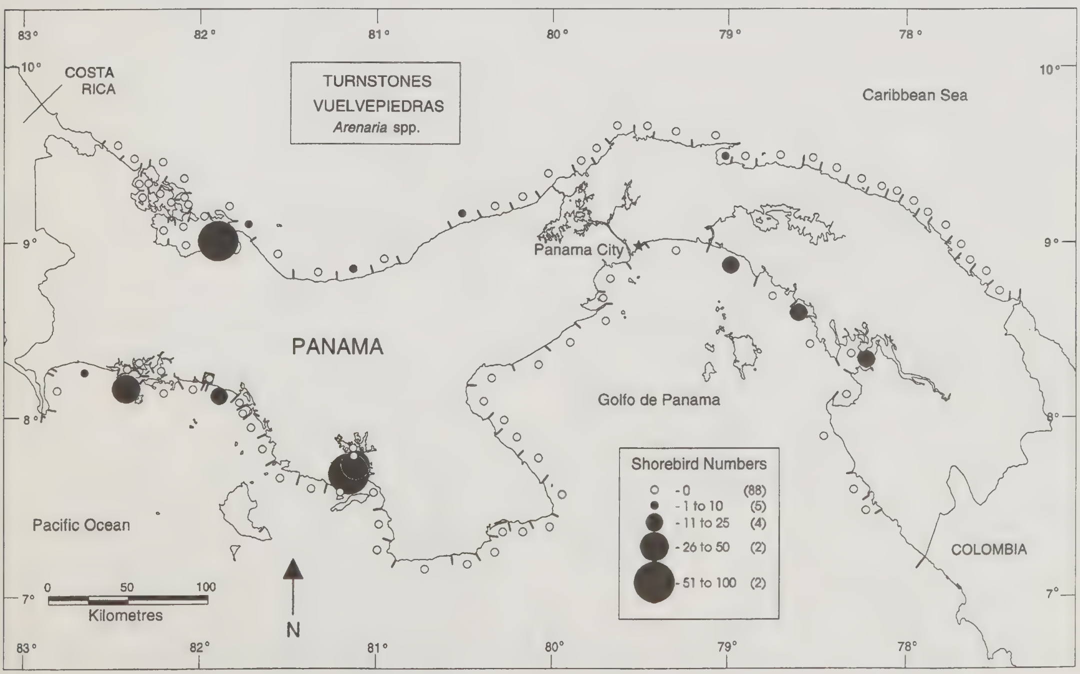

**Map 5.6**
Distribution of Black-bellied Plovers *Pluvialis squatarola* on the coast of Panama during aerial surveys in January 1993



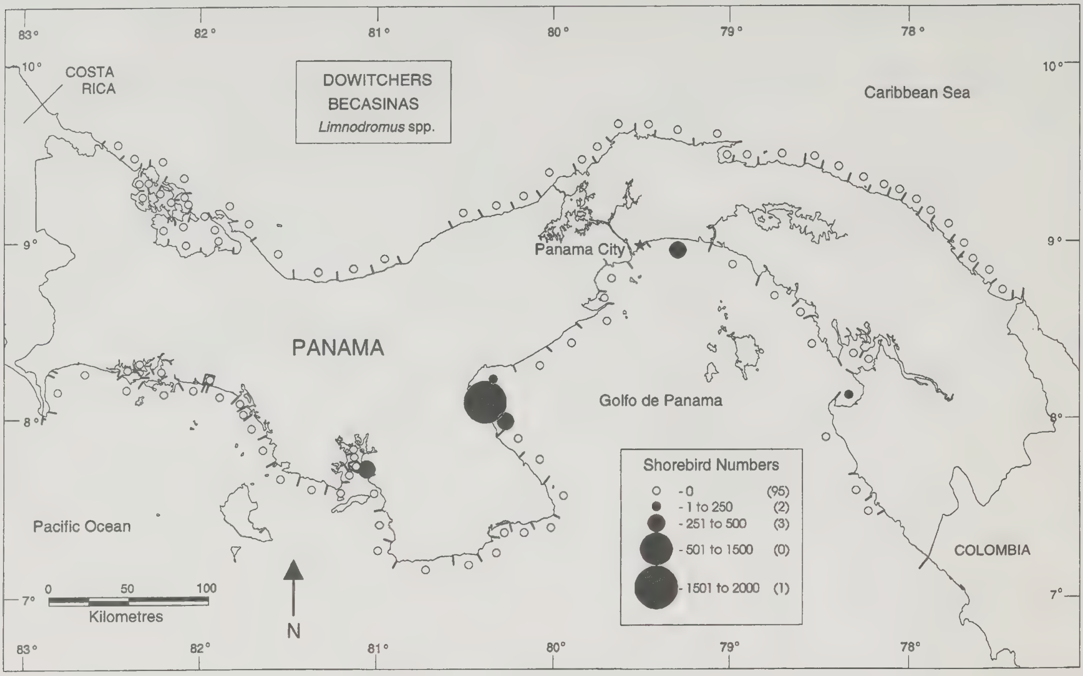
**Map 5.7**
Distribution of yellowlegs *Tringa melanoleuca* and *Tringa flavipes* on the coast of Panama during aerial surveys in January 1993



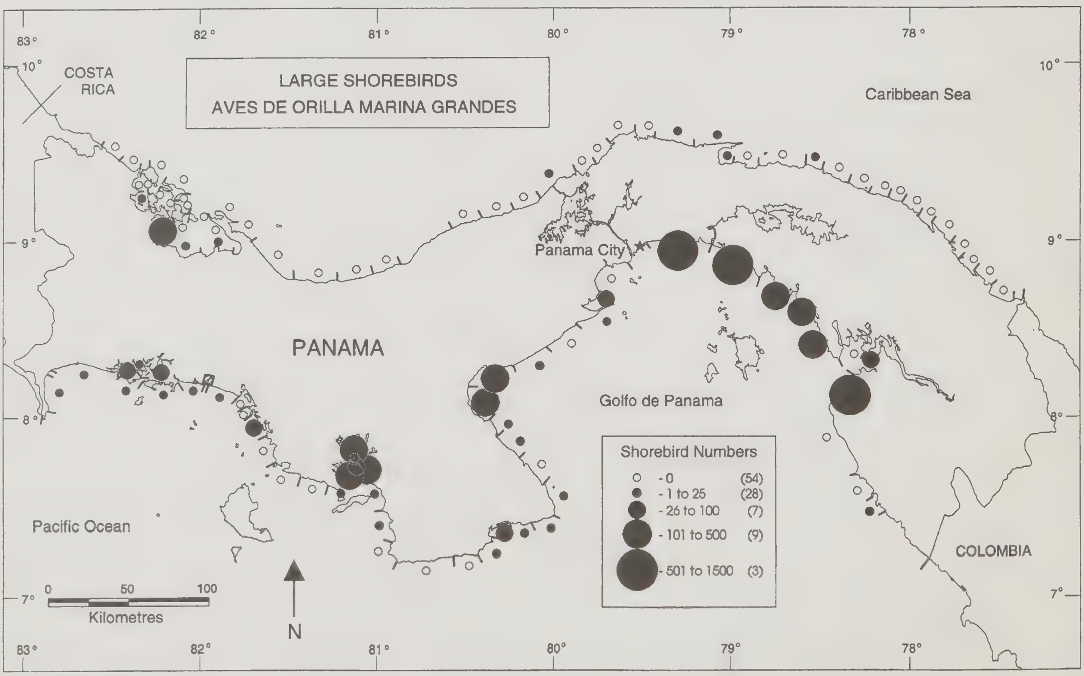

**Map 5.8**
Distribution of Ruddy Turnstones *Arenaria interpres* on the coast of Panama during aerial surveys in January 1993



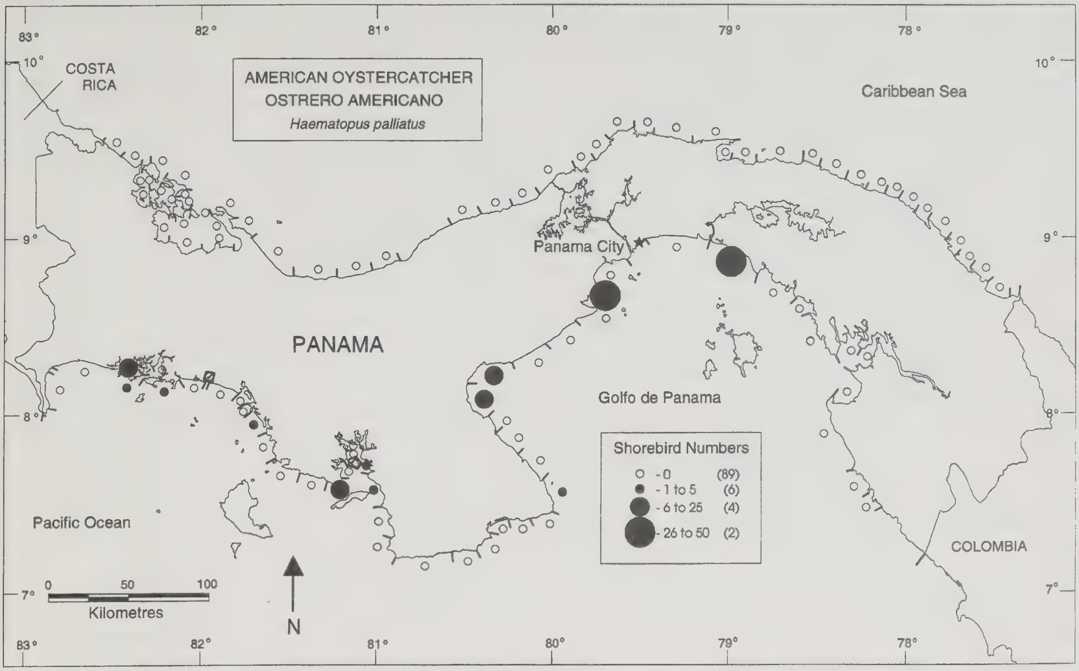
**Map 5.9**
Distribution of dowitchers *Limnodromus* spp. on the coast of Panama during aerial surveys in January 1993



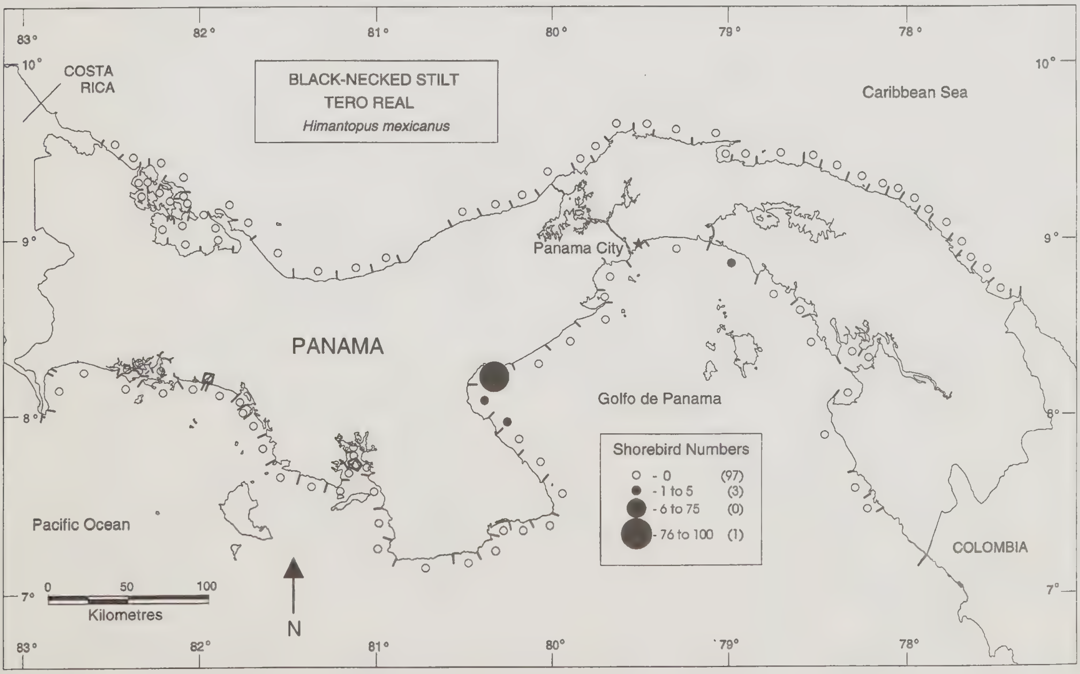

**Map 5.10**
Distribution of large shorebirds on the coast of Panama during aerial surveys in January 1993



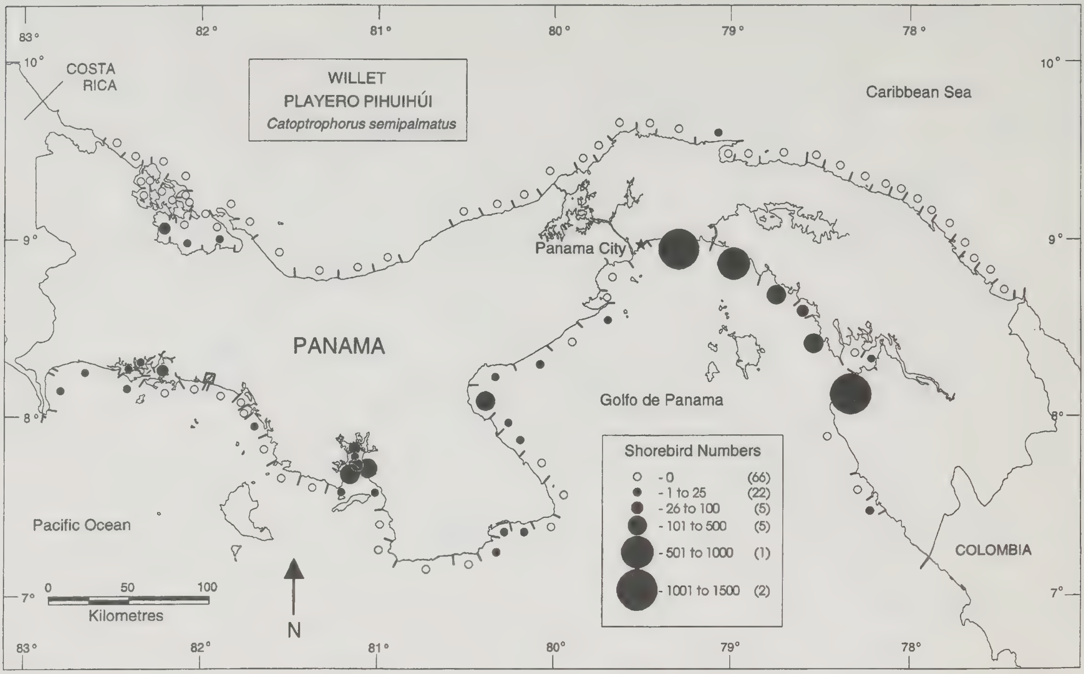
**Map 5.11**
Distribution of American Oystercatchers *Haematopus palliatus* on the coast of Panama during aerial surveys in January 1993




**Map 5.12**
Distribution of Black-necked Stilts *Himantopus mexicanus* on the coast of Panama during aerial surveys in January 1993



**Map. 5.13**
Distribution of Willets *Catoptrophorus semipalmatus* on the coast of Panama during aerial surveys in January 1993




**Map 5.14**
Distribution of Whimbrels *Numenius phaeopus* on the coast of Panama during aerial surveys in January 1993

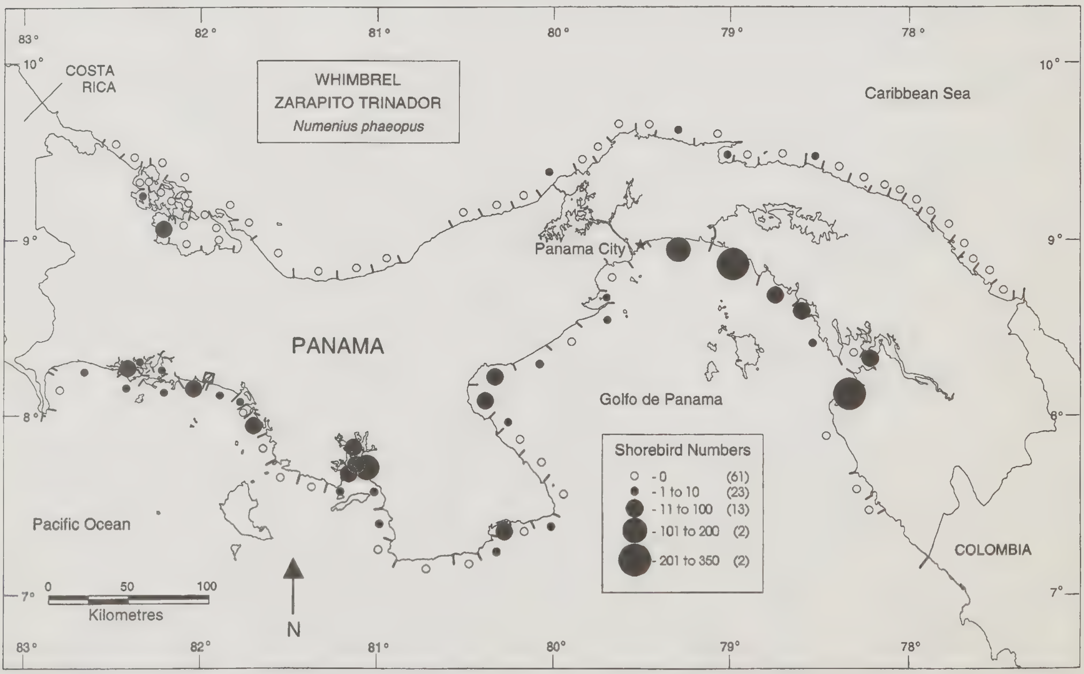


**Table 5.1**
Totals of Nearctic shorebirds counted on the Caribbean and Pacific coasts of Panama during aerial surveys in January 1993

| | | Sector length (km) | Small shorebirds | % | Medium-sized shorebirds | % | Large shorebirds | % | Total shorebirds | % |
|---|---|---|---|---|---|---|---|---|---|---|
| Caribbean coast (Sectors 1–50) | | 1 220 | 160 | *0.1* | 170 | *1.4* | 143 | *2.3* | 473 | *0.2* |
| | % | | *33.8* | | *35.9* | | *30.2* | | *100.0* | |
| Pacific coast (Sectors 51–107) | | 1 668 | 236 207 | *99.9* | 12 095 | *98.6* | 6 079 | *97.7* | 254 381 | *99.8* |
| | % | | *92.9* | | *4.8* | | *2.4* | | *100.0* | |
| Both coasts (Sectors 1–107) | | 2 888 | 236 367 | *100.0* | 12 265 | *100.0* | 6 222 | *100.0* | 254 854 | *100.0* |
| | % | | *92.7* | | *4.8* | | *2.4* | | *100.0* | |

Table 5.2
Summary of totals of small, medium-sized, and large shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Total small shorebirds | % | Total medium-sized shorebirds | % | Total large shorebirds | % | Total shorebirds | % |
|---|---|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | | | |
| 1 | 16.5 | 2 | *0.0* | 2 | *0.0* | 0 | *0.0* | 4 | *0.0* |
| 2 | 15.8 | 1 | *0.0* | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 3 | 23.9 | 1 | *0.0* | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 4 | 19.1 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 5 | 10.8 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 6 | 16.7 | 1 | *0.0* | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 7 | 17.5 | 10 | *0.0* | 2 | *0.0* | 0 | *0.0* | 12 | *0.0* |
| 8 | 18.5 | 5 | *0.0* | 0 | *0.0* | 0 | *0.0* | 5 | *0.0* |
| 9 | 37.6 | 2 | *0.0* | 0 | *0.0* | 0 | *0.0* | 2 | *0.0* |
| 10 | 17.5 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 11 | 19.6 | 3 | *0.0* | 0 | *0.0* | 0 | *0.0* | 3 | *0.0* |
| 12 | 44.4 | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* | 1 | *0.0* |
| 13 | 44.6 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 14 | 48.6 | 4 | *0.0* | 25 | *0.2* | 127 | *2.0* | 156 | *0.1* |
| 15 | 26.0 | 8 | *0.0* | 15 | *0.1* | 3 | *0.0* | 26 | *0.0* |
| 16 | 32.1 | 20 | *0.0* | 76 | *0.6* | 3 | *0.0* | 99 | *0.0* |
| 17 | 39.4 | 14 | *0.0* | 10 | *0.1* | 0 | *0.0* | 24 | *0.0* |
| 18 | 32.6 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 19 | 26.4 | 1 | *0.0* | 3 | *0.0* | 0 | *0.0* | 4 | *0.0* |
| 20 | 39.0 | 45 | *0.0* | 0 | *0.0* | 0 | *0.0* | 45 | *0.0* |
| 21 | 30.2 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 22 | 21.6 | 0 | *0.0* | 1 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 23 | 21.1 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 24 | n.s. | | | | | | | | |
| 25 | 21.9 | 0 | *0.0* | 4 | *0.0* | 0 | *0.0* | 4 | *0.0* |
| 26 | 20.9 | 1 | *0.0* | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 27 | 22.5 | 2 | *0.0* | 0 | *0.0* | 0 | *0.0* | 2 | *0.0* |
| 28 | 54.1 | 4 | *0.0* | 6 | *0.0* | 2 | *0.0* | 12 | *0.0* |
| 29 | 28.7 | 1 | *0.0* | 1 | *0.0* | 0 | *0.0* | 2 | *0.0* |
| 30 | 18.4 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 31 | 22.4 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 32 | 25.5 | 0 | *0.0* | 1 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 33 | 29.5 | 1 | *0.0* | 1 | *0.0* | 1 | *0.0* | 3 | *0.0* |
| 34 | 30.1 | 30 | *0.0* | 12 | *0.1* | 4 | *0.1* | 46 | *0.0* |
| 35 | 37.4 | 0 | *0.0* | 11 | *0.1* | 1 | *0.0* | 12 | *0.0* |
| 36 | 21.9 | 3 | *0.0* | 0 | *0.0* | 0 | *0.0* | 3 | *0.0* |
| 37 | 40.5 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 38 | 11.8 | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* | 1 | *0.0* |
| 39 | 23.0 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 40 | 15.1 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 41 | 14.3 | 1 | *0.0* | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 42 | 12.2 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 43 | 15.6 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 44 | 25.9 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 45 | 22.3 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 46 | 24.3 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 47 | 19.8 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 48 | 21.0 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 49 | 21.7 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 50 | n.s. | | | | | | | | |
| **Pacific coast** | | | | | | | | | |
| 51 | n.s. | | | | | | | | |
| 52 | 30.2 | 0 | *0.0* | 0 | *0.0* | 2 | *0.0* | 2 | *0.0* |
| 53 | 24.6 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 54 | 58.0 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 55 | 45.3 | 6 300 | *2.7* | 272 | *2.2* | 1 326 | *21.3* | 7 898 | *3.1* |
| 56 | 57.7 | 85 | *0.0* | 160 | *1.3* | 25 | *0.4* | 270 | *0.1* |
| 57 | 59.4 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |

*Continued*

**Table 5.2** *(cont'd)*
Summary of totals of small, medium-sized, and large shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Total small shorebirds | % | Total medium-sized shorebirds | % | Total large shorebirds | % | Total shorebirds | % |
|---|---|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 40 | *0.0* | 0 | *0.0* | 225 | *3.6* | 265 | *0.1* |
| 59 | 38.0 | 10 | *0.0* | 74 | *0.6* | 168 | *2.7* | 252 | *0.1* |
| 60 | 48.5 | 1 804 | *0.8* | 300 | *2.4* | 348 | *5.6* | 2 452 | *1.0* |
| 61 | 40.1 | 38 843 | *16.4* | 334 | *2.7* | 988 | *15.9* | 40 165 | *15.8* |
| 62 | 44.2 | 166 345 | *70.4* | 1 953 | *15.9* | 1 350 | *21.7* | 169 648 | *66.6* |
| 63 | n.s. | | | | | | | | |
| 64 | 30.9 | 6 700 | *2.8* | 40 | *0.3* | 0 | *0.0* | 6 740 | *2.6* |
| 65 | 40.7 | 7 000 | *3.0* | 800 | *6.5* | 46 | *0.7* | 7 846 | *3.1* |
| 66 | 30.8 | 10 | *0.0* | 100 | *0.8* | 7 | *0.1* | 117 | *0.0* |
| 67 | 23.9 | 0 | *0.0* | 1 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 68 | 24.6 | 25 | *0.0* | 22 | *0.2* | 23 | *0.4* | 70 | *0.0* |
| 69 | 37.4 | 495 | *0.2* | 175 | *1.4* | 169 | *2.7* | 839 | *0.3* |
| 70 | 31.9 | 3 473 | *1.5* | 6 145 | *50.1* | 360 | *5.8* | 9 978 | *3.9* |
| 71 | 12.3 | 150 | *0.1* | 350 | *2.9* | 7 | *0.1* | 507 | *0.2* |
| 72 | 24.9 | 87 | *0.0* | 0 | *0.0* | 1 | *0.0* | 88 | *0.0* |
| 73 | 21.9 | 9 | *0.0* | 0 | *0.0* | 0 | *0.0* | 9 | *0.0* |
| 74 | 22.6 | 1 | *0.0* | 1 | *0.0* | 1 | *0.0* | 3 | *0.0* |
| 75 | 15.9 | 1 | *0.0* | 2 | *0.0* | 1 | *0.0* | 4 | *0.0* |
| 76 | 26.5 | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* | 1 | *0.0* |
| 77 | 18.2 | 91 | *0.0* | 3 | *0.0* | 37 | *0.6* | 131 | *0.1* |
| 78 | 19.3 | 0 | *0.0* | 1 | *0.0* | 3 | *0.0* | 4 | *0.0* |
| 79 | 21.3 | 1 | *0.0* | 0 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 80 | 33.9 | 2 | *0.0* | 0 | *0.0* | 0 | *0.0* | 2 | *0.0* |
| 81 | 18.8 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 82 | 31.7 | 0 | *0.0* | 0 | *0.0* | 2 | *0.0* | 2 | *0.0* |
| 83 | 27.1 | 33 | *0.0* | 2 | *0.0* | 21 | *0.3* | 56 | *0.0* |
| 84 | 33.2 | 202 | *0.1* | 391 | *3.2* | 418 | *6.7* | 1 011 | *0.4* |
| 85 | 36.6 | 0 | *0.0* | 1 | *0.0* | 115 | *1.8* | 116 | *0.0* |
| 86 | 8.6 | 0 | *0.0* | 3 | *0.0* | 12 | *0.2* | 15 | *0.0* |
| 87 | 18.0 | 258 | *0.1* | 180 | *1.5* | 51 | *0.8* | 489 | *0.2* |
| 88 | 19.5 | 0 | *0.0* | 80 | *0.7* | 175 | *2.8* | 255 | *0.1* |
| 89 | 13.5 | 13 | *0.0* | 2 | *0.0* | 9 | *0.1* | 24 | *0.0* |
| 90 | 23.6 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 91 | 41.4 | 2 | *0.0* | 0 | *0.0* | 0 | *0.0* | 2 | *0.0* |
| 92 | 33.9 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 93 | 45.0 | 251 | *0.1* | 11 | *0.1* | 32 | *0.5* | 294 | *0.1* |
| 94 | 7.1 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 95 | 31.7 | 2 | *0.0* | 0 | *0.0* | 1 | *0.0* | 3 | *0.0* |
| 96 | 35.2 | 321 | *0.1* | 16 | *0.1* | 1 | *0.0* | 338 | *0.1* |
| 97 | 18.4 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 98 | 18.7 | 31 | *0.0* | 11 | *0.1* | 19 | *0.3* | 61 | *0.0* |
| 99 | 51.9 | 182 | *0.1* | 20 | *0.2* | 2 | *0.0* | 204 | *0.1* |
| 100 | 52.8 | 0 | *0.0* | 70 | *0.6* | 70 | *1.1* | 140 | *0.1* |
| 101 | 51.5 | 2 | *0.0* | 0 | *0.0* | 4 | *0.1* | 6 | *0.0* |
| 102 | 25.0 | 316 | *0.1* | 35 | *0.3* | 6 | *0.1* | 357 | *0.1* |
| 103 | 26.9 | 2 685 | *1.1* | 470 | *3.8* | 45 | *0.7* | 3 200 | *1.3* |
| 104 | 44.4 | 433 | *0.2* | 69 | *0.6* | 7 | *0.1* | 509 | *0.2* |
| 105 | n.s. | | | | | | | | |
| 106 | 22.4 | 4 | *0.0* | 1 | *0.0* | 1 | *0.0* | 6 | *0.0* |
| 107 | n.s. | | | | | | | | |
| 1–50 | 1 220.3 | 160 | *0.1* | 170 | *1.4* | 143 | *2.3* | 473 | *0.2* |
| 51–107 | 1 668.1 | 236 207 | *99.9* | 12 095 | *98.6* | 6 079 | *97.7* | 254 381 | *99.8* |
| 1–107 | 2 888.4 | 236 367 | *100.0* | 12 265 | *100.0* | 6 222 | *100.0* | 254 854 | *100.0* |

n.s. = not surveyed

**Table 5.3**
Totals of small shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Spotted Sandpiper | Sanderling | Unidentified small shorebirds | Total small shorebirds |
|---|---|---|---|---|---|
| **Caribbean coast** | | | | | |
| 1 | 16.5 | 2 | 0 | 0 | 2 |
| 2 | 15.8 | 1 | 0 | 0 | 1 |
| 3 | 23.9 | 1 | 0 | 0 | 1 |
| 4 | 19.1 | 0 | 0 | 0 | 0 |
| 5 | 10.8 | 0 | 0 | 0 | 0 |
| 6 | 16.7 | 1 | 0 | 0 | 1 |
| 7 | 17.5 | 10 | 0 | 0 | 10 |
| 8 | 18.5 | 5 | 0 | 0 | 5 |
| 9 | 37.6 | 2 | 0 | 0 | 2 |
| 10 | 17.5 | 0 | 0 | 0 | 0 |
| 11 | 19.6 | 3 | 0 | 0 | 3 |
| 12 | 44.4 | 0 | 0 | 0 | 0 |
| 13 | 44.6 | 0 | 0 | 0 | 0 |
| 14 | 48.6 | 4 | 0 | 0 | 4 |
| 15 | 26.0 | 8 | 0 | 0 | 8 |
| 16 | 32.1 | 5 | 15 | 0 | 20 |
| 17 | 39.4 | 14 | 0 | 0 | 14 |
| 18 | 32.6 | 0 | 0 | 0 | 0 |
| 19 | 26.4 | 1 | 0 | 0 | 1 |
| 20 | 39.0 | 0 | 45 | 0 | 45 |
| 21 | 30.2 | 0 | 0 | 0 | 0 |
| 22 | 21.6 | 0 | 0 | 0 | 0 |
| 23 | 21.1 | 0 | 0 | 0 | 0 |
| 24 | n.s. | | | | |
| 25 | 21.9 | 0 | 0 | 0 | 0 |
| 26 | 20.9 | 1 | 0 | 0 | 1 |
| 27 | 22.5 | 2 | 0 | 0 | 2 |
| 28 | 54.1 | 3 | 1 | 0 | 4 |
| 29 | 28.7 | 1 | 0 | 0 | 1 |
| 30 | 18.4 | 0 | 0 | 0 | 0 |
| 31 | 22.4 | 0 | 0 | 0 | 0 |
| 32 | 25.5 | 0 | 0 | 0 | 0 |
| 33 | 29.5 | 1 | 0 | 0 | 1 |
| 34 | 30.1 | 0 | 0 | 30 | 30 |
| 35 | 37.4 | 0 | 0 | 0 | 0 |
| 36 | 21.9 | 3 | 0 | 0 | 3 |
| 37 | 40.5 | 0 | 0 | 0 | 0 |
| 38 | 11.8 | 0 | 0 | 0 | 0 |
| 39 | 23.0 | 0 | 0 | 0 | 0 |
| 40 | 15.1 | 0 | 0 | 0 | 0 |
| 41 | 14.3 | 1 | 0 | 0 | 1 |
| 42 | 12.2 | 0 | 0 | 0 | 0 |
| 43 | 15.6 | 0 | 0 | 0 | 0 |
| 44 | 25.9 | 0 | 0 | 0 | 0 |
| 45 | 22.3 | 0 | 0 | 0 | 0 |
| 46 | 24.3 | 0 | 0 | 0 | 0 |
| 47 | 19.8 | 0 | 0 | 0 | 0 |
| 48 | 21.0 | 0 | 0 | 0 | 0 |
| 49 | 21.7 | 0 | 0 | 0 | 0 |
| 50 | n.s. | | | | |
| **Pacific coast** | | | | | |
| 51 | n.s. | | | | |
| 52 | 30.2 | 0 | 0 | 0 | 0 |
| 53 | 24.6 | 0 | 0 | 0 | 0 |
| 54 | 58.0 | 0 | 0 | 0 | 0 |
| 55 | 45.3 | 0 | 0 | 6 300 | 6 300 |
| 56 | 57.7 | 0 | 0 | 85 | 85 |
| 57 | 59.4 | 0 | 0 | 0 | 0 |

*Continued*

**Table 5.3** *(cont'd)*
Totals of small shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Spotted Sandpiper | Sanderling | Unidentified small shorebirds | Total small shorebirds |
|---|---|---|---|---|---|
| 58 | 48.2 | 0 | 20 | 20 | 40 |
| 59 | 38.0 | 0 | 0 | 10 | 10 |
| 60 | 48.5 | 4 | 0 | 1 800 | 1 804 |
| 61 | 40.1 | 0 | 165 | 38 678 | 38 843 |
| 62 | 44.2 | 0 | 0 | 166 345 | 166 345 |
| 63 | n.s. | | | | |
| 64 | 30.9 | 0 | 0 | 6 700 | 6 700 |
| 65 | 40.7 | 0 | 0 | 7 000 | 7 000 |
| 66 | 30.8 | 0 | 10 | 0 | 10 |
| 67 | 23.9 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 25 | 0 | 25 |
| 69 | 37.4 | 0 | 0 | 495 | 495 |
| 70 | 31.9 | 0 | 0 | 3 473 | 3 473 |
| 71 | 12.3 | 0 | 0 | 150 | 150 |
| 72 | 24.9 | 0 | 37 | 50 | 87 |
| 73 | 21.9 | 1 | 8 | 0 | 9 |
| 74 | 22.6 | 0 | 1 | 0 | 1 |
| 75 | 15.9 | 1 | 0 | 0 | 1 |
| 76 | 26.5 | 0 | 0 | 0 | 0 |
| 77 | 18.2 | 0 | 85 | 6 | 91 |
| 78 | 19.3 | 0 | 0 | 0 | 0 |
| 79 | 21.3 | 0 | 1 | 0 | 1 |
| 80 | 33.9 | 2 | 0 | 0 | 2 |
| 81 | 18.8 | 0 | 0 | 0 | 0 |
| 82 | 31.7 | 0 | 0 | 0 | 0 |
| 83 | 27.1 | 0 | 3 | 30 | 33 |
| 84 | 33.2 | 2 | 0 | 200 | 202 |
| 85 | 36.6 | 0 | 0 | 0 | 0 |
| 86 | 8.6 | 0 | 0 | 0 | 0 |
| 87 | 18.0 | 8 | 0 | 250 | 258 |
| 88 | 19.5 | 0 | 0 | 0 | 0 |
| 89 | 13.5 | 8 | 5 | 0 | 13 |
| 90 | 23.6 | 0 | 0 | 0 | 0 |
| 91 | 41.4 | 2 | 0 | 0 | 2 |
| 92 | 33.9 | 0 | 0 | 0 | 0 |
| 93 | 45.0 | 0 | 1 | 250 | 251 |
| 94 | 7.1 | 0 | 0 | 0 | 0 |
| 95 | 31.7 | 2 | 0 | 0 | 2 |
| 96 | 35.2 | 0 | 321 | 0 | 321 |
| 97 | 18.4 | 0 | 0 | 0 | 0 |
| 98 | 18.7 | 1 | 30 | 0 | 31 |
| 99 | 51.9 | 2 | 85 | 95 | 182 |
| 100 | 52.8 | 0 | 0 | 0 | 0 |
| 101 | 51.5 | 2 | 0 | 0 | 2 |
| 102 | 25.0 | 0 | 10 | 306 | 316 |
| 103 | 26.9 | 0 | 0 | 2 685 | 2 685 |
| 104 | 44.4 | 0 | 143 | 290 | 433 |
| 105 | n.s. | | | | |
| 106 | 22.4 | 4 | 0 | 0 | 4 |
| 107 | n.s. | | | | |
| 1–50 | 1 220.3 | 69 | 61 | 30 | 160 |
| 51–107 | 1 668.1 | 39 | 950 | 235 218 | 236 207 |
| 1–107 | 2 888.4 | 108 | 1 011 | 235 248 | 236 367 |

n.s. = not surveyed

**Table 5.4**
Totals of medium-sized shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Black-bellied Plover | Ruddy Turnstone | Dowitchers | Yellowlegs | Unidentified medium-sized shorebirds | Total medium-sized shorebirds |
|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | |
| 1 | 16.5 | 2 | 0 | 0 | 0 | 0 | 2 |
| 2 | 15.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 19.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 10.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 16.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 17.5 | 2 | 0 | 0 | 0 | 0 | 2 |
| 8 | 18.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 37.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 17.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 19.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 44.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 44.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 48.6 | 3 | 0 | 0 | 0 | 22 | 25 |
| 15 | 26.0 | 15 | 0 | 0 | 0 | 0 | 15 |
| 16 | 32.1 | 18 | 58 | 0 | 0 | 0 | 76 |
| 17 | 39.4 | 10 | 0 | 0 | 0 | 0 | 10 |
| 18 | 32.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 26.4 | 0 | 3 | 0 | 0 | 0 | 3 |
| 20 | 39.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 30.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 21.6 | 0 | 1 | 0 | 0 | 0 | 1 |
| 23 | 21.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | n.s. | | | | | | |
| 25 | 21.9 | 1 | 3 | 0 | 0 | 0 | 4 |
| 26 | 20.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 22.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 54.1 | 6 | 0 | 0 | 0 | 0 | 6 |
| 29 | 28.7 | 1 | 0 | 0 | 0 | 0 | 1 |
| 30 | 18.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 22.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | 25.5 | 1 | 0 | 0 | 0 | 0 | 1 |
| 33 | 29.5 | 1 | 0 | 0 | 0 | 0 | 1 |
| 34 | 30.1 | 12 | 0 | 0 | 0 | 0 | 12 |
| 35 | 37.4 | 0 | 1 | 0 | 0 | 10 | 11 |
| 36 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 40.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 11.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | 23.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 15.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | 14.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42 | 12.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | 15.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 44 | 25.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 45 | 22.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46 | 24.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 47 | 19.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 48 | 21.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49 | 21.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | n.s. | | | | | | |
| **Pacific coast** | | | | | | | |
| 51 | n.s. | | | | | | |
| 52 | 30.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 53 | 24.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 54 | 58.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 55 | 45.3 | 2 | 0 | 100 | 0 | 170 | 272 |
| 56 | 57.7 | 0 | 10 | 0 | 0 | 150 | 160 |
| 57 | 59.4 | 0 | 0 | 0 | 0 | 0 | 0 |

*Continued*

**Table 5.4** *(cont'd)*
Totals of medium-sized shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Black-bellied Plover | Ruddy Turnstone | Dowitchers | Yellowlegs | Unidentified medium-sized shorebirds | Total medium-sized shorebirds |
|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 6 | 18 | 0 | 0 | 50 | 74 |
| 60 | 48.5 | 0 | 0 | 0 | 0 | 300 | 300 |
| 61 | 40.1 | 12 | 22 | 0 | 0 | 300 | 334 |
| 62 | 44.2 | 153 | 0 | 400 | 0 | 1 400 | 1 953 |
| 63 | n.s. | | | | | | |
| 64 | 30.9 | 0 | 0 | 0 | 0 | 40 | 40 |
| 65 | 40.7 | 0 | 0 | 0 | 0 | 800 | 800 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 100 | 100 |
| 67 | 23.9 | 0 | 0 | 0 | 1 | 0 | 1 |
| 68 | 24.6 | 0 | 0 | 0 | 1 | 21 | 22 |
| 69 | 37.4 | 0 | 0 | 145 | 0 | 30 | 175 |
| 70 | 31.9 | 32 | 0 | 1 761 | 2 | 4 350 | 6 145 |
| 71 | 12.3 | 0 | 0 | 350 | 0 | 0 | 350 |
| 72 | 24.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 74 | 22.6 | 0 | 0 | 0 | 0 | 1 | 1 |
| 75 | 15.9 | 0 | 0 | 0 | 0 | 2 | 2 |
| 76 | 26.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 77 | 18.2 | 3 | 0 | 0 | 0 | 0 | 3 |
| 78 | 19.3 | 1 | 0 | 0 | 0 | 0 | 1 |
| 79 | 21.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81 | 18.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 82 | 31.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 83 | 27.1 | 2 | 0 | 0 | 0 | 0 | 2 |
| 84 | 33.2 | 1 | 0 | 320 | 0 | 70 | 391 |
| 85 | 36.6 | 1 | 0 | 0 | 0 | 0 | 1 |
| 86 | 8.6 | 3 | 0 | 0 | 0 | 0 | 3 |
| 87 | 18.0 | 0 | 30 | 0 | 0 | 150 | 180 |
| 88 | 19.5 | 0 | 80 | 0 | 0 | 0 | 80 |
| 89 | 13.5 | 2 | 0 | 0 | 0 | 0 | 2 |
| 90 | 23.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 41.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 92 | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 93 | 45.0 | 11 | 0 | 0 | 0 | 0 | 11 |
| 94 | 7.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 95 | 31.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 96 | 35.2 | 5 | 11 | 0 | 0 | 0 | 16 |
| 97 | 18.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 98 | 18.7 | 5 | 0 | 0 | 0 | 6 | 11 |
| 99 | 51.9 | 0 | 0 | 0 | 0 | 20 | 20 |
| 100 | 52.8 | 70 | 0 | 0 | 0 | 0 | 70 |
| 101 | 51.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 102 | 25.0 | 0 | 30 | 0 | 0 | 5 | 35 |
| 103 | 26.9 | 0 | 0 | 0 | 0 | 470 | 470 |
| 104 | 44.4 | 61 | 4 | 0 | 0 | 4 | 69 |
| 105 | n.s. | | | | | | |
| 106 | 22.4 | 0 | 0 | 0 | 0 | 1 | 1 |
| 107 | n.s. | | | | | | |
| 1–50 | 1 220.3 | 72 | 66 | 0 | 0 | 32 | 170 |
| 51–107 | 1 668.1 | 370 | 205 | 3 076 | 4 | 8 440 | 12 095 |
| 1–107 | 2 888.4 | 442 | 271 | 3 076 | 4 | 8 472 | 12 265 |

n.s. = not surveyed

**Table 5.5**
Totals of large shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Whimbrel | Willet | American Oystercatcher | Black-necked Stilt | Unidentified large shorebirds | Total large shorebirds |
|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | |
| 1 | 16.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 15.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 19.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 10.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 16.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 17.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 18.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 37.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 17.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 19.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 44.4 | 1 | 0 | 0 | 0 | 0 | 1 |
| 13 | 44.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 48.6 | 82 | 45 | 0 | 0 | 0 | 127 |
| 15 | 26.0 | 0 | 3 | 0 | 0 | 0 | 3 |
| 16 | 32.1 | 0 | 3 | 0 | 0 | 0 | 3 |
| 17 | 39.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 32.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 26.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 39.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 30.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 21.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 21.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | n.s. | | | | | | |
| 25 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 20.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 22.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 54.1 | 2 | 0 | 0 | 0 | 0 | 2 |
| 29 | 28.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 18.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 22.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | 25.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | 29.5 | 1 | 0 | 0 | 0 | 0 | 1 |
| 34 | 30.1 | 0 | 4 | 0 | 0 | 0 | 4 |
| 35 | 37.4 | 1 | 0 | 0 | 0 | 0 | 1 |
| 36 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 40.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 11.8 | 1 | 0 | 0 | 0 | 0 | 1 |
| 39 | 23.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 15.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | 14.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42 | 12.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | 15.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 44 | 25.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 45 | 22.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46 | 24.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 47 | 19.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 48 | 21.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49 | 21.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | n.s. | | | | | | |
| **Pacific coast** | | | | | | | |
| 51 | n.s. | | | | | | |
| 52 | 30.2 | 0 | 2 | 0 | 0 | 0 | 2 |
| 53 | 24.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 54 | 58.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 55 | 45.3 | 226 | 1100 | 0 | 0 | 0 | 1326 |
| 56 | 57.7 | 15 | 10 | 0 | 0 | 0 | 25 |
| 57 | 59.4 | 0 | 0 | 0 | 0 | 0 | 0 |

*Continued*

**Table 5.5** *(cont'd)*
Totals of large shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Whimbrel | Willet | American Oystercatcher | Black-necked Stilt | Unidentified large shorebirds | Total large shorebirds |
|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 5 | 220 | 0 | 0 | 0 | 225 |
| 59 | 38.0 | 86 | 82 | 0 | 0 | 0 | 168 |
| 60 | 48.5 | 90 | 218 | 0 | 0 | 40 | 348 |
| 61 | 40.1 | 342 | 605 | 40 | 1 | 0 | 988 |
| 62 | 44.2 | 162 | 1188 | 0 | 0 | 0 | 1350 |
| 63 | n.s. | | | | | | |
| 64 | 30.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 65 | 40.7 | 1 | 0 | 45 | 0 | 0 | 46 |
| 66 | 30.8 | 1 | 1 | 0 | 0 | 5 | 7 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 2 | 21 | 0 | 0 | 0 | 23 |
| 69 | 37.4 | 51 | 9 | 19 | 80 | 10 | 169 |
| 70 | 31.9 | 66 | 271 | 20 | 3 | 0 | 360 |
| 71 | 12.3 | 1 | 4 | 0 | 2 | 0 | 7 |
| 72 | 24.9 | 0 | 1 | 0 | 0 | 0 | 1 |
| 73 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 74 | 22.6 | 0 | 0 | 1 | 0 | 0 | 1 |
| 75 | 15.9 | 1 | 0 | 0 | 0 | 0 | 1 |
| 76 | 26.5 | 0 | 1 | 0 | 0 | 0 | 1 |
| 77 | 18.2 | 22 | 15 | 0 | 0 | 0 | 37 |
| 78 | 19.3 | 1 | 2 | 0 | 0 | 0 | 3 |
| 79 | 21.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81 | 18.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 82 | 31.7 | 2 | 0 | 0 | 0 | 0 | 2 |
| 83 | 27.1 | 2 | 15 | 4 | 0 | 0 | 21 |
| 84 | 33.2 | 191 | 225 | 2 | 0 | 0 | 418 |
| 85 | 36.6 | 73 | 42 | 0 | 0 | 0 | 115 |
| 86 | 8.6 | 7 | 5 | 0 | 0 | 0 | 12 |
| 87 | 18.0 | 17 | 34 | 0 | 0 | 0 | 51 |
| 88 | 19.5 | 50 | 125 | 0 | 0 | 0 | 175 |
| 89 | 13.5 | 1 | 1 | 7 | 0 | 0 | 9 |
| 90 | 23.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 41.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 92 | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 93 | 45.0 | 20 | 10 | 2 | 0 | 0 | 32 |
| 94 | 7.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 95 | 31.7 | 1 | 0 | 0 | 0 | 0 | 1 |
| 96 | 35.2 | 1 | 0 | 0 | 0 | 0 | 1 |
| 97 | 18.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 98 | 18.7 | 19 | 0 | 0 | 0 | 0 | 19 |
| 99 | 51.9 | 1 | 0 | 1 | 0 | 0 | 2 |
| 100 | 52.8 | 5 | 65 | 0 | 0 | 0 | 70 |
| 101 | 51.5 | 2 | 2 | 0 | 0 | 0 | 4 |
| 102 | 25.0 | 2 | 2 | 2 | 0 | 0 | 6 |
| 103 | 26.9 | 15 | 20 | 10 | 0 | 0 | 45 |
| 104 | 44.4 | 5 | 2 | 0 | 0 | 0 | 7 |
| 105 | n.s. | | | | | | |
| 106 | 22.4 | 0 | 1 | 0 | 0 | 0 | 1 |
| 107 | n.s. | | | | | | |
| 1–50 | 1220.3 | 88 | 55 | 0 | 0 | 0 | 143 |
| 51–107 | 1668.1 | 1486 | 4299 | 153 | 86 | 55 | 6079 |
| 1–107 | 2888.4 | 1574 | 4354 | 153 | 86 | 55 | 6222 |

n.s. = not surveyed

**Table 5.6**
Totals of shorebirds counted during aerial surveys of the coast of the Golfo de Panama in February 1988, October 1991, and January 1993

| Sector | Sector length (km) | Total small shorebirds | % | Total medium-sized shorebirds | % | Total large shorebirds | % | Total shorebirds | % |
|---|---|---|---|---|---|---|---|---|---|
| **February 1988** | | | | | | | | | |
| 55 | 45.3 | 2 000 | *1.2* | 480 | *5.1* | 2 442 | *16.1* | 4 922 | *2.7* |
| 56 | 57.7 | 8 100 | *5.0* | 1 700 | *18.1* | 317 | *2.1* | 10 117 | *5.5* |
| 57 | 59.4 | 61 | *0.0* | 83 | *0.9* | 671 | *4.4* | 815 | *0.4* |
| 58 | 48.2 | 56 | *0.0* | 0 | *0.0* | 31 | *0.2* | 87 | *0.0* |
| 59 | 38.0 | 573 | *0.4* | 327 | *3.5* | 245 | *1.6* | 1 145 | *0.6* |
| 60 | 48.5 | 330 | *0.2* | 308 | *3.3* | 1 493 | *9.8* | 2 131 | *1.1* |
| 61 | 40.1 | 35 095 | *21.8* | 1 897 | *20.2* | 6 868 | *45.2* | 43 860 | *23.7* |
| 62 | 44.2 | 102 763 | *63.9* | 1 757 | *18.8* | 1 751 | *11.5* | 106 271 | *57.3* |
| 63 | n.s. | | | | | | | | |
| 64 | 30.9 | 8 608 | *5.4* | 338 | *3.6* | 342 | *2.3* | 9 288 | *5.0* |
| 65 | 40.7 | 522 | *0.3* | 1 085 | *11.6* | 404 | *2.7* | 2 011 | *1.1* |
| 66 | 30.8 | 15 | *0.0* | 21 | *0.2* | 30 | *0.2* | 66 | *0.0* |
| 67 | 23.9 | 0 | *0.0* | 0 | *0.0* | 2 | *0.0* | 2 | *0.0* |
| 68 | 24.6 | 60 | *0.0* | 1 | *0.0* | 6 | *0.0* | 67 | *0.0* |
| 69 | 37.4 | 1 039 | *0.6* | 623 | *6.6* | 123 | *0.8* | 1 785 | *1.0* |
| 70 | 31.9 | 1 500 | *0.9* | 706 | *7.5* | 453 | *3.0* | 2 659 | *1.4* |
| 71 | 12.3 | 56 | *0.0* | 44 | *0.5* | 18 | *0.1* | 118 | *0.1* |
| | 613.9 | 160 778 | *100.0* | 9 370 | *100.0* | 15 196 | *100.0* | 185 344 | *100.0* |
| **October 1991** | | | | | | | | | |
| 55 | 45.3 | 70 | *0.0* | 252 | *1.9* | 2 035 | *7.6* | 2 357 | *0.6* |
| 56 | 57.7 | 330 | *0.1* | 332 | *2.5* | 72 | *0.3* | 734 | *0.2* |
| 57 | 59.4 | 1 805 | *0.5* | 382 | *2.9* | 116 | *0.4* | 2 303 | *0.6* |
| 58 | 48.2 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 59 | 38.0 | 274 | *0.1* | 216 | *1.6* | 106 | *0.4* | 596 | *0.2* |
| 60 | 48.5 | 5 770 | *1.8* | 1 495 | *11.4* | 3 802 | *14.2* | 11 067 | *3.0* |
| 61 | 40.1 | 13 341 | *4.1* | 4 160 | *31.8* | 10 581 | *39.6* | 28 082 | *7.6* |
| 62 | 44.2 | 293 340 | *89.1* | 4 042 | *30.9* | 7 625 | *28.5* | 305 007 | *82.6* |
| 63 | n.s. | | | | | | | | |
| 64 | 30.9 | 3 416 | *1.0* | 253 | *1.9* | 528 | *2.0* | 4 197 | *1.1* |
| 65 | 40.7 | 164 | *0.0* | 44 | *0.3* | 366 | *1.4* | 574 | *0.2* |
| 66 | 30.8 | 13 | *0.0* | 0 | *0.0* | 16 | *0.1* | 29 | *0.0* |
| 67 | 23.9 | 17 | *0.0* | 0 | *0.0* | 9 | *0.0* | 26 | *0.0* |
| 68 | 24.6 | 41 | *0.0* | 2 | *0.0* | 55 | *0.2* | 98 | *0.0* |
| 69 | 37.4 | 987 | *0.3* | 364 | *2.8* | 217 | *0.8* | 1 568 | *0.4* |
| 70 | 31.9 | 9 690 | *2.9* | 1 553 | *11.9* | 1 199 | *4.5* | 12 442 | *3.4* |
| 71 | 12.3 | 25 | *0.0* | 4 | *0.0* | 5 | *0.0* | 34 | *0.0* |
| | 613.9 | 329 283 | *100.0* | 13 099 | *100.0* | 26 732 | *100.0* | 369 114 | *100.0* |
| **January 1993** | | | | | | | | | |
| 55 | 45.3 | 6 300 | *2.7* | 272 | *2.5* | 1 326 | *26.3* | 7 898 | *3.2* |
| 56 | 57.7 | 85 | *0.0* | 160 | *1.5* | 25 | *0.5* | 270 | *0.1* |
| 57 | 59.4 | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* |
| 58 | 48.2 | 40 | *0.0* | 0 | *0.0* | 225 | *4.5* | 265 | *0.1* |
| 59 | 38.0 | 10 | *0.0* | 74 | *0.7* | 168 | *3.3* | 252 | *0.1* |
| 60 | 48.5 | 1 804 | *0.8* | 300 | *2.8* | 348 | *6.9* | 2 452 | *1.0* |
| 61 | 40.1 | 38 843 | *16.8* | 334 | *3.1* | 988 | *19.6* | 40 165 | *16.3* |
| 62 | 44.2 | 166 345 | *71.9* | 1 953 | *18.2* | 1 350 | *26.8* | 169 648 | *68.7* |
| 63 | n.s. | | | | | | | | |
| 64 | 30.9 | 6 700 | *2.9* | 40 | *0.4* | 0 | *0.0* | 6 740 | *2.7* |
| 65 | 40.7 | 7 000 | *3.0* | 800 | *7.5* | 46 | *0.9* | 7 846 | *3.2* |
| 66 | 30.8 | 10 | *0.0* | 100 | *0.9* | 7 | *0.1* | 117 | *0.0* |
| 67 | 23.9 | 0 | *0.0* | 1 | *0.0* | 0 | *0.0* | 1 | *0.0* |
| 68 | 24.6 | 25 | *0.0* | 22 | *0.2* | 23 | *0.5* | 70 | *0.0* |
| 69 | 37.4 | 495 | *0.2* | 175 | *1.6* | 169 | *3.4* | 839 | *0.3* |
| 70 | 31.9 | 3 473 | *1.5* | 6 145 | *57.3* | 360 | *7.1* | 9 978 | *4.0* |
| 71 | 12.3 | 150 | *0.1* | 350 | *3.3* | 7 | *0.1* | 507 | *0.2* |
| | 613.9 | 231 280 | *100.0* | 10 726 | *100.0* | 5 042 | *100.0* | 247 048 | *100.0* |

n.s. = not surveyed

**Table 5.7**
Totals of small shorebirds counted during aerial surveys of the coast of the Golfo de Panama in February 1988, October 1991, and January 1993

| Sector | Sector length (km) | Spotted Sandpiper | Sanderling | Unidentified small shorebirds | Total small shorebirds |
|---|---|---|---|---|---|
| **February 1988** | | | | | |
| 55 | 45.3 | 0 | 0 | 2 000 | 2 000 |
| 56 | 57.7 | 0 | 0 | 8 100 | 8 100 |
| 57 | 59.4 | 1 | 0 | 60 | 61 |
| 58 | 48.2 | 2 | 0 | 54 | 56 |
| 59 | 38.0 | 3 | 0 | 570 | 573 |
| 60 | 48.5 | 0 | 0 | 330 | 330 |
| 61 | 40.1 | 0 | 3 | 35 092 | 35 095 |
| 62 | 44.2 | 0 | 0 | 102 763 | 102 763 |
| 63 | n.s. | | | | |
| 64 | 30.9 | 0 | 0 | 8 608 | 8 608 |
| 65 | 40.7 | 0 | 137 | 385 | 522 |
| 66 | 30.8 | 0 | 15 | 0 | 15 |
| 67 | 23.9 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 60 | 0 | 60 |
| 69 | 37.4 | 0 | 1 | 1 038 | 1 039 |
| 70 | 31.9 | 0 | 2 | 1 498 | 1 500 |
| 71 | 12.3 | 0 | 6 | 50 | 56 |
| | 613.9 | 6 | 224 | 160 548 | 160 778 |
| **October 1991** | | | | | |
| 55 | 45.3 | 0 | 0 | 70 | 70 |
| 56 | 57.7 | 0 | 0 | 330 | 330 |
| 57 | 59.4 | 0 | 0 | 1 805 | 1 805 |
| 58 | n.s. | | | | |
| 59 | 38.0 | 0 | 0 | 274 | 274 |
| 60 | 48.5 | 0 | 0 | 5 770 | 5 770 |
| 61 | 40.1 | 0 | 0 | 13 341 | 13 341 |
| 62 | 44.2 | 0 | 0 | 293 340 | 293 340 |
| 63 | n.s. | | | | |
| 64 | 30.9 | 0 | 200 | 3 216 | 3 416 |
| 65 | 40.7 | 0 | 75 | 89 | 164 |
| 66 | 30.8 | 0 | 12 | 1 | 13 |
| 67 | 23.9 | 0 | 16 | 1 | 17 |
| 68 | 24.6 | 0 | 36 | 5 | 41 |
| 69 | 37.4 | 1 | 0 | 986 | 987 |
| 70 | 31.9 | 0 | 0 | 9 690 | 9 690 |
| 71 | 12.3 | 0 | 4 | 21 | 25 |
| | 613.9 | 1 | 343 | 328 939 | 329 283 |
| **January 1993** | | | | | |
| 55 | 45.3 | 0 | 0 | 6 300 | 6 300 |
| 56 | 57.7 | 0 | 0 | 85 | 85 |
| 57 | 59.4 | 0 | 0 | 0 | 0 |
| 58 | 48.2 | 0 | 20 | 20 | 40 |
| 59 | 38.0 | 0 | 0 | 10 | 10 |
| 60 | 48.5 | 4 | 0 | 1 800 | 1 804 |
| 61 | 40.1 | 0 | 165 | 38 678 | 38 843 |
| 62 | 44.2 | 0 | 0 | 166 345 | 166 345 |
| 63 | n.s. | | | | |
| 64 | 30.9 | 0 | 0 | 6 700 | 6 700 |
| 65 | 40.7 | 0 | 0 | 7 000 | 7 000 |
| 66 | 30.8 | 0 | 10 | 0 | 10 |
| 67 | 23.9 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 25 | 0 | 25 |
| 69 | 37.4 | 0 | 0 | 495 | 495 |
| 70 | 31.9 | 0 | 0 | 3 473 | 3 473 |
| 71 | 12.3 | 0 | 0 | 150 | 150 |
| | 613.9 | 4 | 220 | 231 056 | 231 280 |

n.s. = not surveyed

**Table 5.8**
Totals of medium-sized shorebirds counted during aerial surveys of the coast of the Golfo de Panama in February 1988, October 1991, and January 1993

| Sector | Sector length (km) | Black-bellied Plover | Killdeer | Yellowlegs | Ruddy Turnstone | Dowitchers | Unidentified medium-sized shorebirds | Total medium-sized shorebirds |
|---|---|---|---|---|---|---|---|---|
| **February 1988** | | | | | | | | |
| 55 | 45.3 | 0 | 0 | 0 | 80 | 0 | 400 | 480 |
| 56 | 57.7 | 0 | 0 | 0 | 0 | 1 500 | 200 | 1 700 |
| 57 | 59.4 | 3 | 0 | 24 | 11 | 15 | 30 | 83 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 12 | 300 | 15 | 327 |
| 60 | 48.5 | 5 | 0 | 1 | 0 | 282 | 20 | 308 |
| 61 | 40.1 | 37 | 0 | 30 | 300 | 65 | 1 465 | 1 897 |
| 62 | 44.2 | 5 | 0 | 12 | 90 | 0 | 1 650 | 1 757 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 125 | 0 | 52 | 0 | 65 | 96 | 338 |
| 65 | 40.7 | 72 | 0 | 2 | 0 | 1 010 | 1 | 1 085 |
| 66 | 30.8 | 9 | 0 | 0 | 0 | 0 | 12 | 21 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 69 | 37.4 | 82 | 0 | 21 | 83 | 223 | 214 | 623 |
| 70 | 31.9 | 152 | 1 | 78 | 3 | 192 | 280 | 706 |
| 71 | 12.3 | 2 | 0 | 27 | 0 | 15 | 0 | 44 |
| | 613.9 | 492 | 1 | 247 | 579 | 3 667 | 4 384 | 9 370 |
| **October 1991** | | | | | | | | |
| 55 | 45.3 | 60 | 0 | 0 | 21 | 21 | 150 | 252 |
| 56 | 57.7 | 132 | 0 | 0 | 80 | 80 | 40 | 332 |
| 57 | 59.4 | 10 | 0 | 0 | 2 | 0 | 370 | 382 |
| 58 | n.s. | | | | | | | |
| 59 | 38.0 | 11 | 0 | 0 | 2 | 3 | 200 | 216 |
| 60 | 48.5 | 166 | 0 | 0 | 2 | 300 | 1 027 | 1 495 |
| 61 | 40.1 | 78 | 0 | 0 | 2 | 4 010 | 70 | 4 160 |
| 62 | 44.2 | 151 | 0 | 1 | 30 | 3 720 | 140 | 4 042 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 36 | 0 | 0 | 2 | 150 | 65 | 253 |
| 65 | 40.7 | 27 | 0 | 0 | 5 | 2 | 10 | 44 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| 69 | 37.4 | 13 | 0 | 1 | 0 | 150 | 200 | 364 |
| 70 | 31.9 | 471 | 0 | 4 | 0 | 1 075 | 3 | 1 553 |
| 71 | 12.3 | 4 | 0 | 0 | 0 | 0 | 0 | 4 |
| | 613.9 | 1 161 | 0 | 6 | 146 | 9 511 | 2 275 | 13 099 |
| **January 1993** | | | | | | | | |
| 55 | 45.3 | 2 | 0 | 0 | 0 | 100 | 170 | 272 |
| 56 | 57.7 | 0 | 0 | 0 | 10 | 0 | 150 | 160 |
| 57 | 59.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 6 | 0 | 0 | 18 | 0 | 50 | 74 |
| 60 | 48.5 | 0 | 0 | 0 | 0 | 0 | 300 | 300 |
| 61 | 40.1 | 12 | 0 | 0 | 22 | 0 | 300 | 334 |
| 62 | 44.2 | 153 | 0 | 0 | 0 | 400 | 1 400 | 1 953 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 0 | 0 | 0 | 0 | 40 | 40 |
| 65 | 40.7 | 0 | 0 | 0 | 0 | 0 | 800 | 800 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| 67 | 23.9 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 68 | 24.6 | 0 | 0 | 1 | 0 | 0 | 21 | 22 |
| 69 | 37.4 | 0 | 0 | 0 | 0 | 145 | 30 | 175 |
| 70 | 31.9 | 32 | 0 | 2 | 0 | 1 761 | 4 350 | 6 145 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 350 | 0 | 350 |
| | 613.9 | 205 | 0 | 4 | 50 | 2 756 | 7 711 | 10 726 |

n.s. = not surveyed

**Table 5.9**
Totals of large shorebirds counted during aerial surveys of the Golfo de Panama in February 1988, October 1991, and January 1993

| Sector | Sector length (km) | Black-necked Stilt | American Oyster-catcher | Marbled Godwit | Willet | Whimbrel | Unidentified large shorebirds | Total large shorebirds |
|---|---|---|---|---|---|---|---|---|
| **February 1988** | | | | | | | | |
| 55 | 45.3 | 0 | 0 | 0 | 1 786 | 656 | 0 | 2 442 |
| 56 | 57.7 | 0 | 2 | 0 | 305 | 10 | 0 | 317 |
| 57 | 59.4 | 0 | 0 | 0 | 401 | 270 | 0 | 671 |
| 58 | 48.2 | 0 | 4 | 0 | 6 | 21 | 0 | 31 |
| 59 | 38.0 | 0 | 2 | 0 | 94 | 149 | 0 | 245 |
| 60 | 48.5 | 0 | 0 | 0 | 648 | 845 | 0 | 1 493 |
| 61 | 40.1 | 80 | 35 | 0 | 5 414 | 1 339 | 0 | 6 868 |
| 62 | 44.2 | 0 | 4 | 0 | 1 604 | 143 | 0 | 1 751 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 7 | 0 | 316 | 19 | 0 | 342 |
| 65 | 40.7 | 0 | 0 | 0 | 188 | 216 | 0 | 404 |
| 66 | 30.8 | 0 | 8 | 0 | 5 | 17 | 0 | 30 |
| 67 | 23.9 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| 68 | 24.6 | 0 | 1 | 0 | 3 | 2 | 0 | 6 |
| 69 | 37.4 | 0 | 3 | 0 | 63 | 57 | 0 | 123 |
| 70 | 31.9 | 1 | 1 | 0 | 140 | 311 | 0 | 453 |
| 71 | 12.3 | 0 | 0 | 0 | 12 | 6 | 0 | 18 |
| | 613.9 | 81 | 67 | 0 | 10 986 | 4 062 | 0 | 15 196 |
| **October 1991** | | | | | | | | |
| 55 | 45.3 | 0 | 0 | 50 | 788 | 550 | 647 | 2 035 |
| 56 | 57.7 | 0 | 0 | 0 | 51 | 21 | 0 | 72 |
| 57 | 59.4 | 0 | 0 | 0 | 99 | 17 | 0 | 116 |
| 58 | n.s. | | | | | | | |
| 59 | 38.0 | 0 | 0 | 2 | 60 | 44 | 0 | 106 |
| 60 | 48.5 | 0 | 2 | 300 | 1 211 | 1 964 | 325 | 3 802 |
| 61 | 40.1 | 3 | 200 | 250 | 7 909 | 1 669 | 550 | 10 581 |
| 62 | 44.2 | 165 | 29 | 100 | 1 919 | 212 | 5 200 | 7 625 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 2 | 0 | 489 | 37 | 0 | 528 |
| 65 | 40.7 | 0 | 0 | 0 | 68 | 298 | 0 | 366 |
| 66 | 30.8 | 0 | 0 | 0 | 9 | 7 | 0 | 16 |
| 67 | 23.9 | 0 | 0 | 0 | 2 | 7 | 0 | 9 |
| 68 | 24.6 | 0 | 0 | 0 | 48 | 7 | 0 | 55 |
| 69 | 37.4 | 0 | 12 | 0 | 172 | 33 | 0 | 217 |
| 70 | 31.9 | 1 | 2 | 0 | 795 | 401 | 0 | 1 199 |
| 71 | 12.3 | 0 | 0 | 0 | 2 | 3 | 0 | 5 |
| | 613.9 | 169 | 247 | 702 | 13 622 | 5 270 | 6 722 | 26 732 |
| **January 1993** | | | | | | | | |
| 55 | 45.3 | 0 | 0 | 0 | 1 100 | 226 | 0 | 1 326 |
| 56 | 57.7 | 0 | 0 | 0 | 10 | 15 | 0 | 25 |
| 57 | 59.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 58 | 48.2 | 0 | 0 | 0 | 220 | 5 | 0 | 225 |
| 59 | 38.0 | 0 | 0 | 0 | 82 | 86 | 0 | 168 |
| 60 | 48.5 | 0 | 0 | 0 | 218 | 90 | 40 | 348 |
| 61 | 40.1 | 1 | 40 | 0 | 605 | 342 | 0 | 988 |
| 62 | 44.2 | 0 | 0 | 0 | 1 188 | 162 | 0 | 1 350 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 65 | 40.7 | 0 | 45 | 0 | 0 | 1 | 0 | 46 |
| 66 | 30.8 | 0 | 0 | 0 | 1 | 1 | 5 | 7 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 0 | 0 | 21 | 2 | 0 | 23 |
| 69 | 37.4 | 80 | 19 | 0 | 9 | 51 | 10 | 169 |
| 70 | 31.9 | 3 | 20 | 0 | 271 | 66 | 0 | 360 |
| 71 | 12.3 | 2 | 0 | 0 | 4 | 1 | 0 | 7 |
| | 613.9 | 86 | 124 | 0 | 3 729 | 1 048 | 55 | 5 042 |

n.s. = not surveyed

# *Chapter 6*
# The distribution and abundance of coastal seabirds, wading birds, and birds of prey on the coast of Panama

R.W. Butler, R.I.G. Morrison, F.S. Delgado, and R.K. Ross

In addition to shorebirds, the Golfo de Panama supports large numbers of coastal seabirds and wading birds each year. Seabirds are numerous in the offshore waters, and internationally important populations of tropical wading birds use the inshore coastal zone (Delgado 1983; Loftin 1991; Butler et al. 1992). During El Niño – Southern Oscillation (ENSO) events, the gulf is believed to be a refugium from food shortages elsewhere in the eastern tropical Pacific Ocean (Engelman 1983; Aid et al. 1985; Smith 1990). Whereas some information is available on the breeding distribution of seabirds (Ridgely and Gwynne 1989) and wading birds (Delgado 1980; Villalaz 1987), the relative abundance of seabirds, wading birds, and birds of prey along the coast of Panama has not been quantified. The purpose of this chapter is to describe the distribution and abundance of coastal seabirds (Pelecaniformes, Charadriiformes other than shorebirds), wading birds (Ciconiiformes), and birds of prey (Falconiformes) in different habitats on the Pacific and Caribbean coasts of Panama.

### 6.1 Distribution of coastal seabirds
*Map 6.1; Tables 6.1, 6.6–6.8*

A total of more than 23 000 coastal seabirds was seen during surveys of the Panamanian coastline in January 1993. Species observed include the Neotropic Cormorant *Phalacrocorax brasilianus*, Brown Pelican *Pelecanus occidentalis*, Magnificent Frigatebird *Fregata magnificens*, and several species of gulls and terns, as well as boobies and tropicbirds. The highest numbers and densities of coastal seabirds were found on the Pacific coast in the Golfo de Panama, especially in Bahia de Parita near Chitre (Sectors 67 and 70), and east of Panama City to Garachine (Sectors 55–62). Lower densities of coastal seabirds were found in the Golfo de Chiriqui (Sectors 92–107) and Golfo de Montijo (Sectors 84–88) on the Pacific coast and Laguna de Chiriqui (Sectors 14–17) on the Caribbean coast.

On the coast of the Golfo de Panama, highest overall numbers of coastal seabirds were seen on the surveys in February 1988 (20 100), with somewhat fewer in January 1993 (17 700) and a lower total again in October 1991 (14 400). Numbers of cormorants and pelicans were highest during February, when upwelling effects in the Golfo de Panama will be in progress (see Chapter 3); numbers of gulls and terns were at their highest levels on the January 1993 surveys.

#### 6.1.1 Red-billed Tropicbird *Phaethon aethereus*
*Table 6.2*

A flock of 100 tropicbirds was seen near a small island breeding colony in Sector 2 near the western end of the Archipielago de Bocas del Toro on the Caribbean coast. This is the only known breeding colony in Panama (Ridgely and Gwynne 1989).

#### 6.1.2 Brown Pelican *Pelecanus occidentalis*
*Map 6.2; Tables 6.2, 6.8*

Of the total of some 3600 pelicans counted on the surveys in January 1993, highest numbers occurred on Pacific coast beaches near Garachine, Panama City, and Bahia de Parita, along the Peninsula de Azuero, and in the Golfo de Chiriqui. On the Caribbean coast, pelicans were most numerous in Laguna de Chiriqui, at the entrance to the Panama Canal, and in western Panama. Breeding is closely allied with seasonal oceanic upwelling, which occurs mostly between January and April in the Golfo de Panama (Montgomery and Martinez 1984). Numbers of pelicans were highest in the Golfo de Panama on the surveys in February 1988. The Brown Pelican is reported to be a widespread and numerous species along both coasts (Ridgely and Gwynne 1989) and in offshore waters of Panama (Loftin 1991). It is only known to breed on offshore islands along the Pacific coast of the country (Wetmore 1965; Montgomery 1982). Nesting occurs on Isla Iguana, near the Peninsula de Azuero, in June, whereas nesting occurs from January to May in offshore colonies (FSD, unpubl. data).

#### 6.1.3 Brown Booby *Sula leucogaster*
*Table 6.2*

A flock of 60 Brown Boobies was recorded on the surveys in January 1993 near the islands off Bocas del Toro, where they are known to breed (Ridgely and Gwynne 1989). Boobies were not recorded in the Golfo de Panama on any of the three sets of surveys. Four species of boobies breed in Panamanian territory (Ridgely and Gwynne 1989), although most tend to be localized around breeding islands and are not frequent in inshore waters.

#### 6.1.4 Neotropic Cormorant *Phalacrocorax brasilianus*
*Map 6.3; Tables 6.2, 6.8*

Nearly all of the total of over 660 cormorants counted in January 1993 were seen in the Golfo de Panama:

highest numbers were found near Panama City, with smaller concentrations in Bahia de Parita and towards Garachine. Very few cormorants were seen outside of the Golfo de Panama: none elsewhere on the Pacific coast, and only small numbers in a few locations along the Caribbean coast.

Within the Golfo de Panama, highest totals of cormorants were counted on the surveys in February 1988 (total 5200, compared with 3800 in October 1991 and 660 in January 1993).

Ridgely and Gwynne (1989) reported the Neotropic Cormorant to be a common species along both coasts of Panama, with especially large numbers in the Golfo de Panama. Loftin (1991) saw no cormorants during shipboard surveys in the Golfo de Panama, which indicates that cormorants inhabit mostly inshore waters. Neotropic Cormorants nest on Lago Bayano from January to March (FSD, unpubl. data).

### 6.1.5 Magnificent Frigatebird *Fregata magnificens*

*Map 6.4; Tables 6.2, 6.8*

Over 420 frigatebirds were counted on the surveys in January 1993, mostly on the Pacific coast, especially in the Golfo de Panama. Exceptional densities were found east of Panama City, whereas lower numbers were observed around other parts of the Golfo de Panama and in the Golfo de Chiriqui. Only nine birds were seen on the Caribbean coast, with individuals scattered around the Laguna de Chiriqui, near the mouth of the Panama Canal, and in the east near the Colombian border.

Frigatebirds were more numerous in the Golfo de Panama in October 1991 (total 1350) and February 1988 (total 400) than in January 1993 (total 350).

The Magnificent Frigatebird is common on the Pacific coast and less numerous on the Caribbean coast (Ridgely and Gwynne 1989). It breeds on islands on the Pacific coast (Ridgely and Gwynne 1989). Over 1000 pairs nest on Isla Iguana near the Peninsula de Azuero.

### 6.1.6 Gulls and terns

*Maps 6.5, 6.6; Tables 6.2, 6.8*

Gulls and terns were generally not identified to species during the aerial surveys. The largest concentrations of both groups in January 1993 occurred on the Pacific coast around the Golfo de Panama (totals of some 9100 gulls and 5900 terns), especially on beaches in Bahia de Parita, east of Panama City, and in the eastern gulf towards Garachine. The most abundant species of terns on beaches near Chitre were the Gull-billed Tern *Sterna nilotica*, Common Tern *S. hirundo*, Bridled Tern *S. anaethetus*, Royal Tern *S. maxima*, Least Tern *S. antillarum*, and Sandwich Tern *S. sandvicensis* (FSD, unpubl. data). The "large tern" category would have consisted mostly of Royal Terns. Gulls and terns were widespread although less numerous along the rest of the Pacific coast, moderate numbers being found in the Golfo de Chiriqui. On the Caribbean coast, numbers were generally lower, with the two groups being found principally along the central part of the coast on either side of the entrance to the Panama Canal and in the west around the Laguna de Chiriqui.

Totals of both gulls and terns were highest in the Golfo de Panama on the January 1993 surveys (9100 and 5900, respectively), with lower totals in February 1988 (3700 and 4700, respectively) and October 1991 (1400 and 2000, respectively).

The Laughing Gull *Larus atricilla* is abundant along the coast of Panama (Wetmore 1965; Ridgely and Gwynne 1989) and in offshore waters of the Golfo de Panama in December through March (Loftin 1991). Loftin (1991) recorded small numbers of Common Tern, Bridled Tern, Royal Tern, and Least Tern and very large numbers of Black Terns *Chlidonias niger* in the Golfo de Panama. We saw no Black Terns during aerial surveys in January 1993, but they are seen irregularly on the Peninsula de Azuero (FSD, pers. obs.). Of these species, only the Bridled Tern is believed to breed in Panama (Ridgely and Gwynne 1989).

### 6.1.7 Black Skimmer *Rynchops niger*

*Table 6.8*

No birds were seen on the surveys of the entire Panamanian coast in January 1993, the only observations being of a flock of 30 skimmers in the Ensenada de Garachine in October 1991. Ridgely and Gwynne (1989) describe the Black Skimmer as a rare and apparently irregular visitant to both coasts.

## 6.2 Distribution of wading birds

*Map 6.7; Tables 6.1, 6.3, 6.6, 6.9*

Wading birds were found in moderately high numbers (total 2200) and densities on nearly all parts of the coastline of Panama. The most numerous wading birds were the Snowy Egret *Egretta thula*, immature Little Blue Heron *E. caerulea*, Great Egret *Ardea alba*, Tricolored Heron *E. tricolor*, Black-crowned Night-Heron *Nycticorax nycticorax*, Yellow-crowned Night-Heron *N. violaceus*, and Great Blue Heron *A. herodias*. We also saw small numbers of White Ibis *Eudocimus albus*, Wood Stork *Mycteria americana*, and Roseate Spoonbill *Ajaia ajaja*.

The Golfo de Panama held the highest densities, especially east and west of Panama City and in the eastern part of the Golfo de Panama near Garachine. Lower, but substantial, numbers were also found in Bahia de Parita and the Golfo de Chiriqui, on the Pacific coast, and in Laguna de Chiriqui and near the entrance of the Panama Canal, on the Caribbean coast. Four species known to breed on the Peninsula de Azuero, but not seen on our surveys, were the Cattle Egret *Bubulcus ibis*, Green Heron *Butorides virescens*, Boat-billed Heron *Cochlearius cochlearius*, and Anhinga *Anhinga anhinga* (Table 6.5).

Highest totals of wading birds in the Golfo de Panama were counted on the surveys in February 1988 (1800), with lower numbers in January 1993 (1500) and October 1991 (970).

### 6.2.1 Great Egret *Ardea alba*

*Map 6.8; Tables 6.3, 6.9*

A total of some 240 Great Egrets was seen on the aerial surveys in January 1993. The species occurred in high densities on both the Pacific and Caribbean coasts, with highest concentrations near Panama City, in Bahia de Parita, and east of Colon. Lower densities were found in the Golfo de Montijo and Golfo de Chiriqui on the Pacific coast and in Laguna de Chiriqui on the northwest coast. Great Egrets occupy freshwater and saltwater habitats in Panama, and the

species is considered numerous throughout the entire year (Ridgely and Gwynne 1989). It nests on coastal islands and in mangroves on the mainland near Chitre and Los Santos. Timing of the breeding season appears to be related to oceanic upwelling: three colonies of egrets near Chitre breed soon after the start of the rainy season when the period of upwelling begins in Bahia de Parita. In 1977, there were 377 nesting pairs of Great Egrets near Parita; in 1985, 15 nests were recorded near Chitre (Table 6.5). Highest numbers on the coast of the Golfo de Panama (120) were recorded in January 1993 (large and small "white egrets" were lumped into a single category on the surveys in February 1988).

### 6.2.2 Great Blue Heron *Ardea herodias*

*Map 6.9; Tables 6.3, 6.9*

Large grey herons seen during the aerial surveys were considered to be nearly entirely Great Blue Herons. Great Blue Herons (total approximately 150) were widespread, with high densities in the Golfo de Panama, near Aguadulce, in the Golfo de Chiriqui, and near David on the Pacific coast. On the Caribbean coast, Great Blue Herons were found in low densities in Archipielago de Bocas del Toro and on the coral reefs between Colon and the coastline of San Blas. Numbers in the Golfo de Panama were lower on the surveys in February 1988 (total 18) and October 1991 (total 20) than on the January 1993 surveys (74).

This species is considered an uncommon winter visitor to Panama; the only other large grey heron, the White-necked Heron *Ardea cocoi*, although generally less numerous, is quite common in freshwater habitats in eastern Panama, and a small colony has been found on Lago Bayano (FSD, unpubl. data; Ridgely and Gwynne 1989). The species is not known to breed south of Mexico, and it is seen in Panama mostly between September and April. These herons are therefore believed to be migrants (Ridgely and Gwynne 1989).

### 6.2.3 Snowy Egret *Egretta thula* and Little Blue Heron *E. caerulea*

*Map 6.10; Tables 6.3, 6.9*

The most numerous small herons seen during the aerial surveys in January 1993 were the Snowy Egret and Little Blue Heron (total 1600). We were unable to distinguish Snowy Egrets from immature Little Blue Herons from the air owing to their similarity in size and colour, and so the two are lumped together as "small white egrets" in Map 6.10 and Tables 6.3 and 6.9. Small herons were widespread on both the Pacific and Caribbean coasts. Highest densities were found in the Golfo de Panama, near Aguadulce, on the south shore of the Peninsula de Azuero, and in Bocas del Toro. Lower densities were found in bays between the Golfo de Chiriqui and David on the Pacific coast, along the coral reefs east of Colon, and along the coastline of San Blas on the Caribbean coast.

In the Golfo de Panama, highest totals of small white egrets were counted in February 1988 (1700), with lower numbers in January 1993 (1200) and October 1991 (620). Small white egrets were most common east and west of Panama City, in the Ensenada de Garachine and other parts of the Golfo de San Miguel, and in Bahia de Parita.

Ridgely and Gwynne (1989) reported the Snowy Egret to be fairly common on both coasts and only known to breed on Changame and Taborcilla islands. However, 10 nests were found near Chitre in 1985 (Table 6.5). Ridgely and Gwynne (1989) stated that the Little Blue Heron is not known to breed in Panama, but FSD (unpubl. data) and Villalaz (1987) found nests of this species near Chitre.

### 6.2.4 Wood Stork *Mycteria americana*

*Table 6.9*

The species was not noted during the aerial surveys in mid-January 1993, although 37 were recorded during aerial surveys of the Golfo de Panama in October 1991, all near Chitre.

The species is uncommon to occasionally common but local and erratic in Panama (Ridgely and Gwynne 1989). Two colonies of Wood Storks are known in Panama: one near Lajas, Chiriqui Province, and another on the southern Peninsula de Azuero. During the dry season, however, flocks of more than 150 storks have been seen in the Azuero wetlands.

### 6.2.5 White Ibis *Eudocimus albus*

*Tables 6.3, 6.9*

Sightings (total 160) on the surveys in January 1993 occurred mostly in the Golfo de Panama, near Garachine and east of Panama City; a few birds were also observed in a mangrove-lined inlet on the south side of the Peninsula de Azuero. In February 1988, 65 ibises were counted in the eastern half of the Golfo de Panama, most in the eastern Golfo de San Miguel. The White Ibis tends to occur mainly on coastal mudflats and mangroves (only occasionally in freshwater habitats) and has been reported between eastern Chiriqui and Darien provinces on the Pacific coast (Ridgely and Gwynne 1989).

### 6.2.6 Roseate Spoonbill *Ajaia ajaja*

*Table 6.9*

The species was not recorded on aerial surveys in January 1993, although a total of 71 was observed during aerial surveys of the Golfo de Panama in October 1991; most (55) were seen near Chitre, the remainder occurring to the east and west of Panama City (Butler et al. 1992). No spoonbills are known to breed in Panama (previously reported to breed up to about 1930; Ridgely and Gwynne 1989), although a few pairs are usually seen during the dry season in mangroves and on mudflats of Azuero and central Panama.

## 6.3 Distribution of birds of prey

*Map 6.11; Tables 6.1, 6.4, 6.6, 6.10*

By far the most numerous bird of prey seen during the aerial surveys was the Black Vulture *Coragyps atratus* (total 200). We also recorded the Peregrine Falcon *Falco peregrinus*, Osprey *Pandion haliaetus*, and Crested Caracara *Polyborus plancus*. Birds of prey were most numerous along the shoreline east and west of Panama City and near Colon. Lower densities were found at scattered locations on both coasts.

### 6.3.1 Osprey *Pandion haliaetus*

*Map 6.12; Tables 6.4, 6.10*

The total of 20 Ospreys seen on aerial surveys in January 1993 was scattered along the Caribbean and Pacific coasts. Six were seen in the Golfo de Chiriqui, four in the Golfo de Panama, three in the Golfo de los Mosquitos, two in Laguna de Chiriqui, and single birds in scattered locations.

The species is more often seen around ponds, lakes, and lagoons during the dry season, and dozens are seen on the Caribbean coast during spring migration (FSD, unpubl. data). On the coast of the Golfo de Panama, the species was most numerous on the surveys in February 1988, when a total of 18 was counted; eight were seen on the surveys of this region in October 1991.

The Osprey does not breed in Panama but is widespread in winter (Ridgely and Gwynne 1989). One Osprey in 1995 and two individuals in 1996 fitted with satellite transmitters in Minnesota, U.S.A., migrated through Panama to South America (J.E. Elliott, unpubl. data).

### 6.3.2 Black Vulture *Coragyps atratus*

*Tables 6.4, 6.10*

We recorded Black Vultures on a number of occasions along beaches, often near fishing villages: highest numbers in the Golfo de Panama were observed in October 1991. The Black Vulture is an abundant member of the Panamanian terrestrial avifauna and is generally much more numerous than survey data indicated. It is found with huge flocks of Turkey Vultures *Cathartes aura* and Broad-winged Hawks *Buteo platypterus* during migration along the isthmus of Panama in October.

### 6.3.3 Crested Caracara *Polyborus plancus*

*Tables 6.4, 6.10*

The Crested Caracara was seen occasionally on the coast, mostly on the Pacific side. It is generally found in open grasslands with trees or scrub (Ridgely and Gwynne 1989).

### 6.3.4 Peregrine Falcon *Falco peregrinus*

*Tables 6.4, 6.10*

One Peregrine Falcon was observed during the aerial surveys in January 1993 near Aguadulce, and one was seen in October 1991 on the western coast of the Golfo de Panama in Sector 67. The Peregrine Falcon is widespread in Panama from October to May and is mostly seen along its coasts (Ridgely and Gwynne 1989), where its prey includes migratory shorebirds. The subspecies found in Panama is probably *F. p. anatum*, which breeds in the Arctic and migrates to Latin America.

## 6.4 Discussion

It is clear from the single series of aerial surveys in mid-January 1993 that the coast of Panama supports a large number of coastal seabirds and wading birds, with especially large concentrations on the Pacific coast. The conclusions that emerge from the surveys are that coastal seabirds and wading birds are generally widespread along both the Pacific and Caribbean coasts and that by far the greatest densities of coastal seabirds and wading birds are found around the Golfo de Panama. These results support and extend previous studies that have found that the Golfo de Panama supports large numbers of coastal seabirds (Loftin 1991), shorebirds (Chapter 5), and wading birds (Butler et al. 1992).

The high bird densities in the Golfo de Panama likely result from the high biological productivity associated with the oceanic upwelling that occurs in the gulf (Chapters 3 and 7). Some seabirds, particularly pelicans and cormorants, were notably abundant in the Golfo de Panama in February 1988, during annual upwelling in the offshore water. The distribution of many seabirds appears to be affected by thermal regimes of ocean water (e.g., Ainley et al. 1988), although it is not known whether the observed variation in seabird population numbers between the present series of surveys is connected with this phenomenon.

A second feature that appears to influence the distribution of coastal birds is the extent of intertidal habitat exposed during low tides. Tidal amplitude is about 5 m on the Pacific coast, compared with less than 1 m on the Caribbean side: mudflats are widespread on the Pacific coast, whereas coral beaches predominate on many parts of the Caribbean coast. Consequently, the intertidal habitat is much more extensive on the Pacific coast than on the Caribbean coast.

On a finer scale, the high densities of coastal birds observed on mudflats backed by mangroves (Butler et al. 1997) suggest that the birds associate with particular coastal habitats within zones of oceanic upwelling, where the high biological productivity is likely to lead to especially abundant food resources. The conservational significance of this finding is that the maintenance of high densities of coastal birds is likely to depend on maintaining mangrove ecosystems. Mangroves provide food and shelter for coastal birds and are especially important in the life cycles of diverse communities of invertebrates and fish. They also provide roost sites for Brown Pelicans, Neotropic Cormorants, Magnificent Frigatebirds, Snowy Egrets, Great Egrets, Great Blue Herons, Little Blue Herons, Yellow-crowned Night-Herons, and Black-crowned Night-Herons. Most seabirds roosted on beaches, mudflats, rocky islets, and headlands after foraging. Mangroves extend for nearly 200 km east of Panama City to Garachine. This area held the highest densities of coastal seabirds and wading birds (Maps 6.1 and 6.7), as well as shorebirds (Chapter 5). Other areas on the Pacific coast with mangroves included the Golfo de Montijo and some of the inlets around the Golfo de Chiriqui, and these areas also held significant numbers of coastal birds. Mangrove stands were less developed and less extensive on the Caribbean coast; the mangrove stands in the Laguna de Chiriqui in Bocas del Toro supported some of the highest numbers of birds on the north coast.

## 6.5 Literature cited

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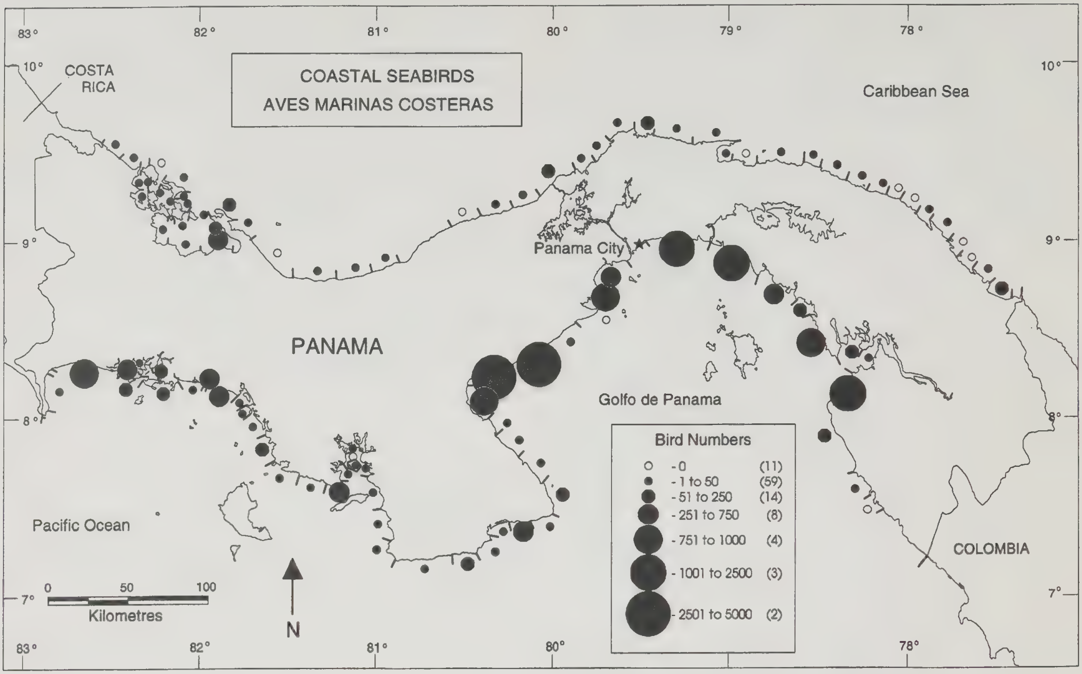
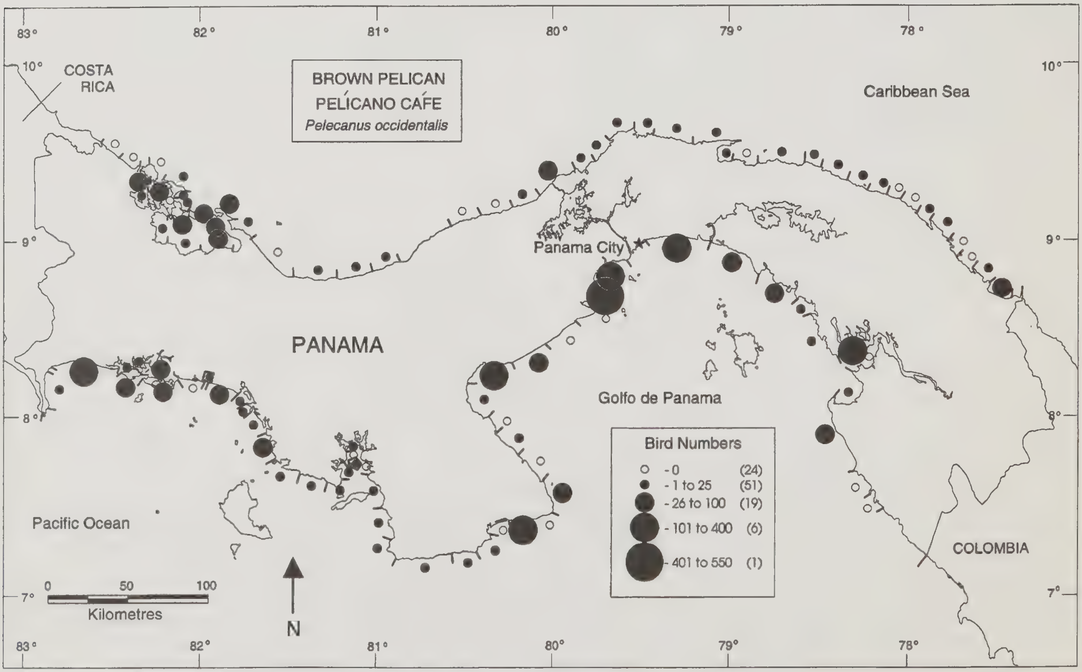
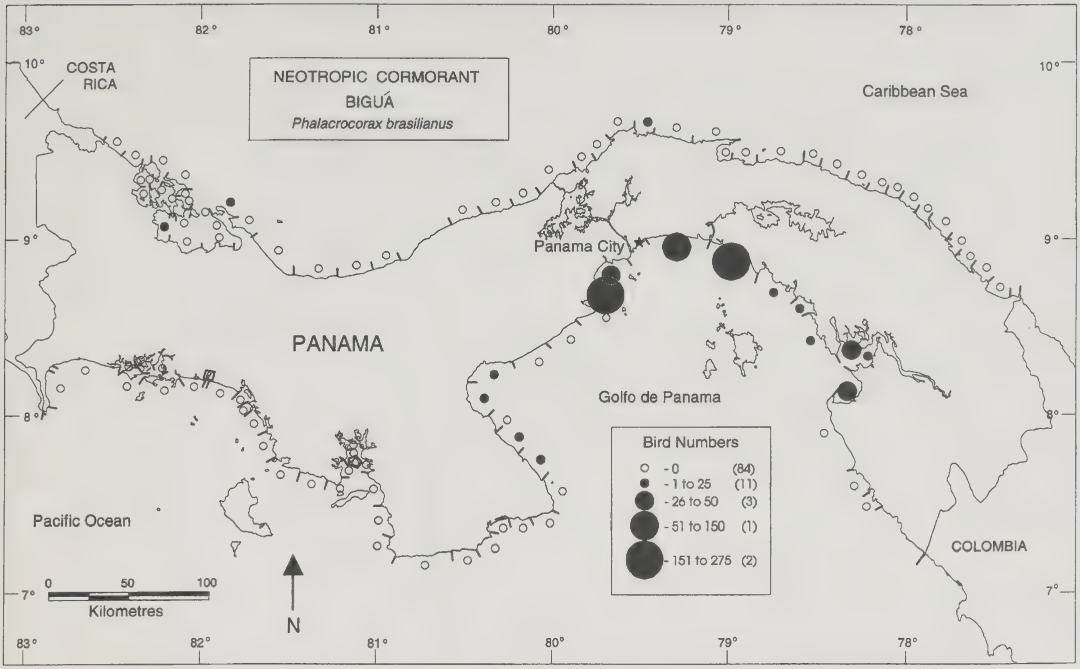
**Map 6.1**
Distribution of coastal seabirds on the coast of Panama during aerial surveys in January 1993



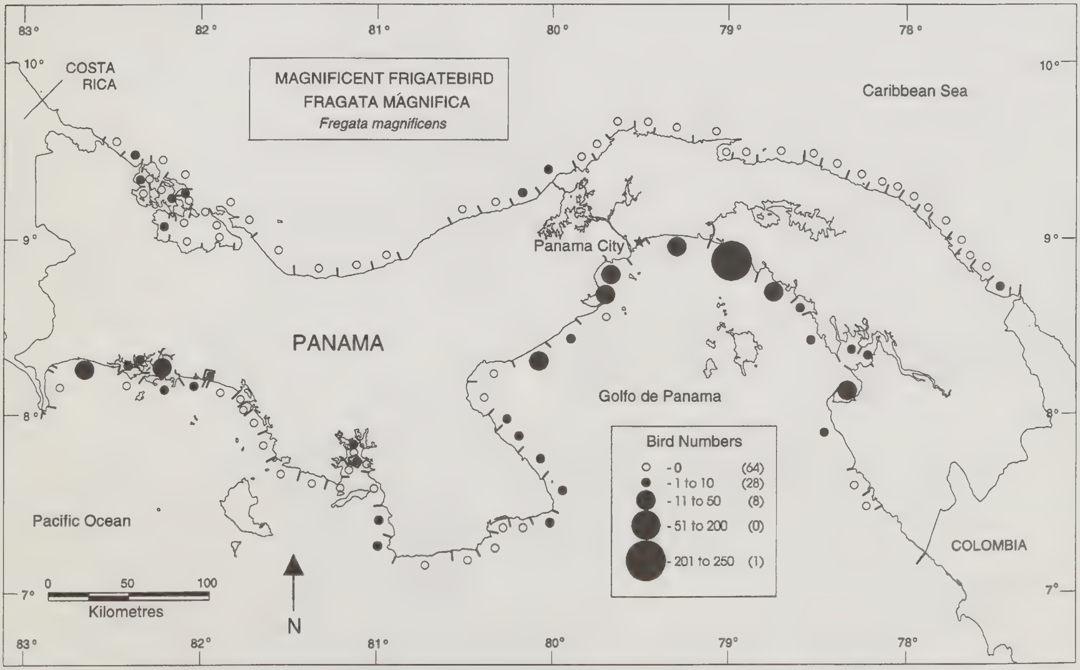

**Map 6.2**
Distribution of Brown Pelicans *Pelecanus occidentalis* on the coast of Panama during aerial surveys in January 1993



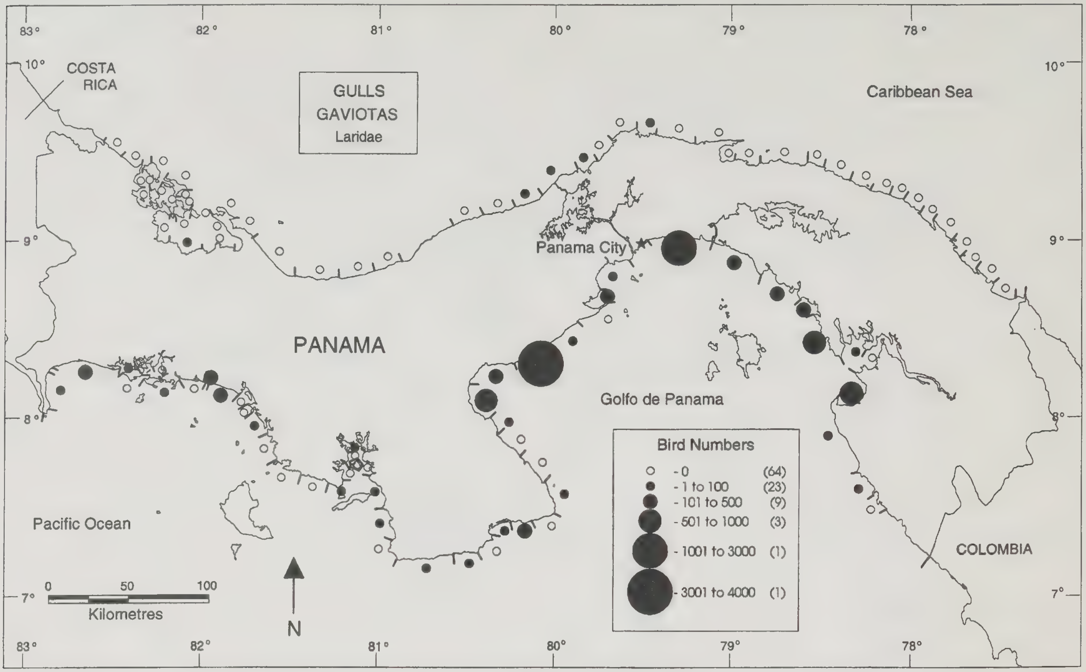
**Map 6.3**
Distribution of Neotropic Cormorants *Phalacrocorax brasilianus* on the coast of Panama during aerial surveys in January 1993



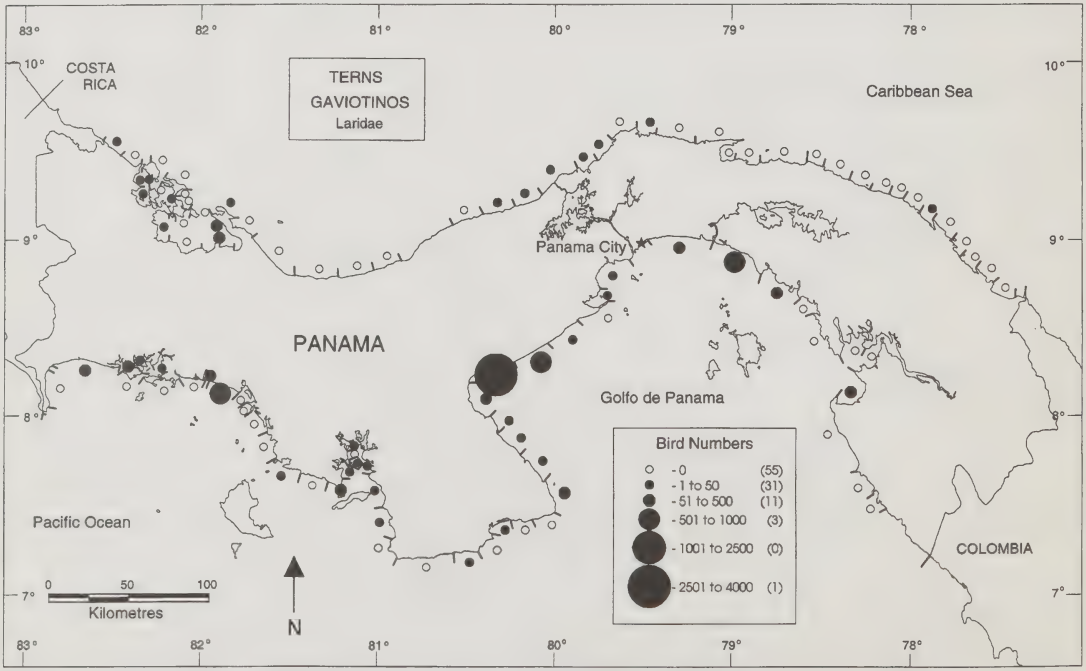

**Map 6.4**
Distribution of Magnificent Frigatebirds *Fregata magnificens* on the coast of Panama during aerial surveys in January 1993



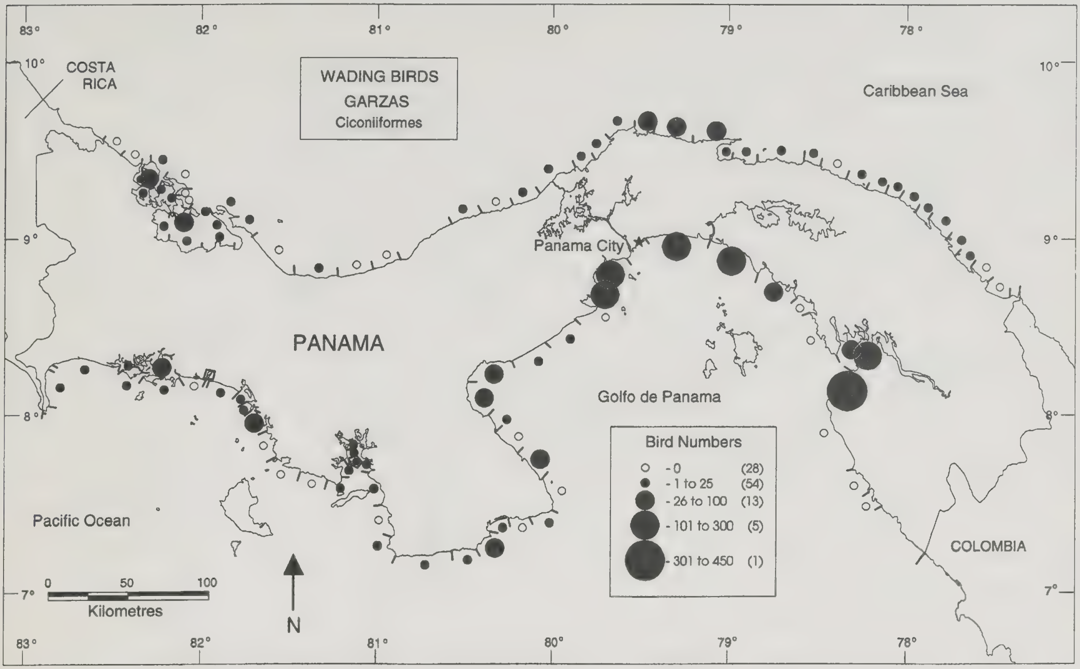
**Map 6.5**
Distribution of gulls on the coast of Panama during aerial surveys in January 1993



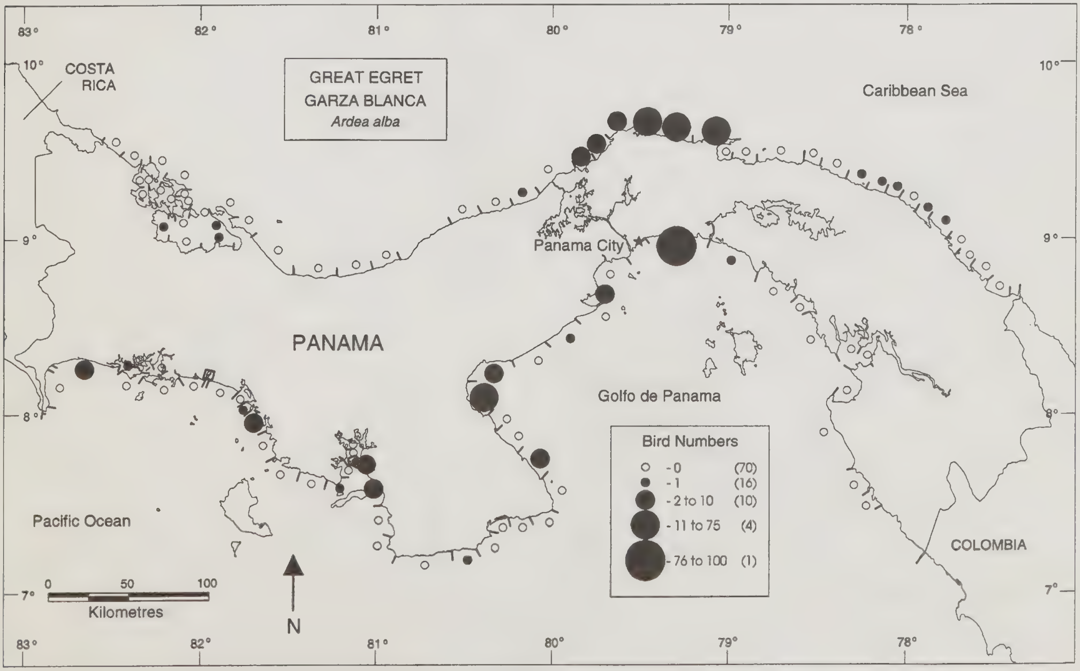

**Map 6.6**
Distribution of terns on the coast of Panama during aerial surveys in January 1993



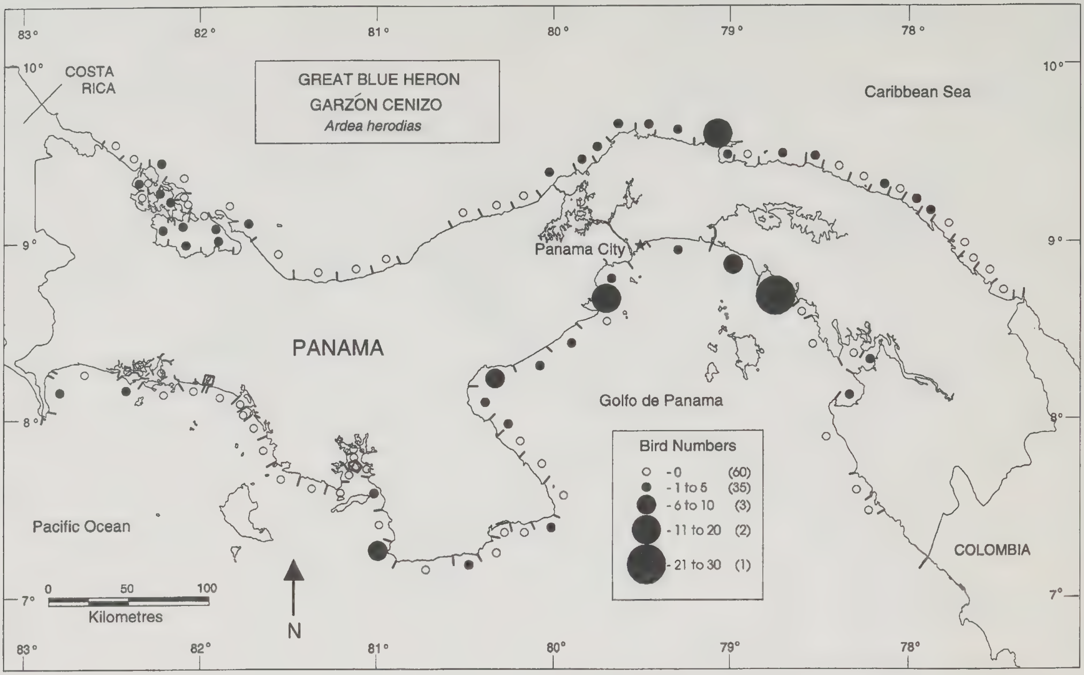
**Map 6.7**
Distribution of wading birds on the coast of Panama during aerial surveys in January 1993



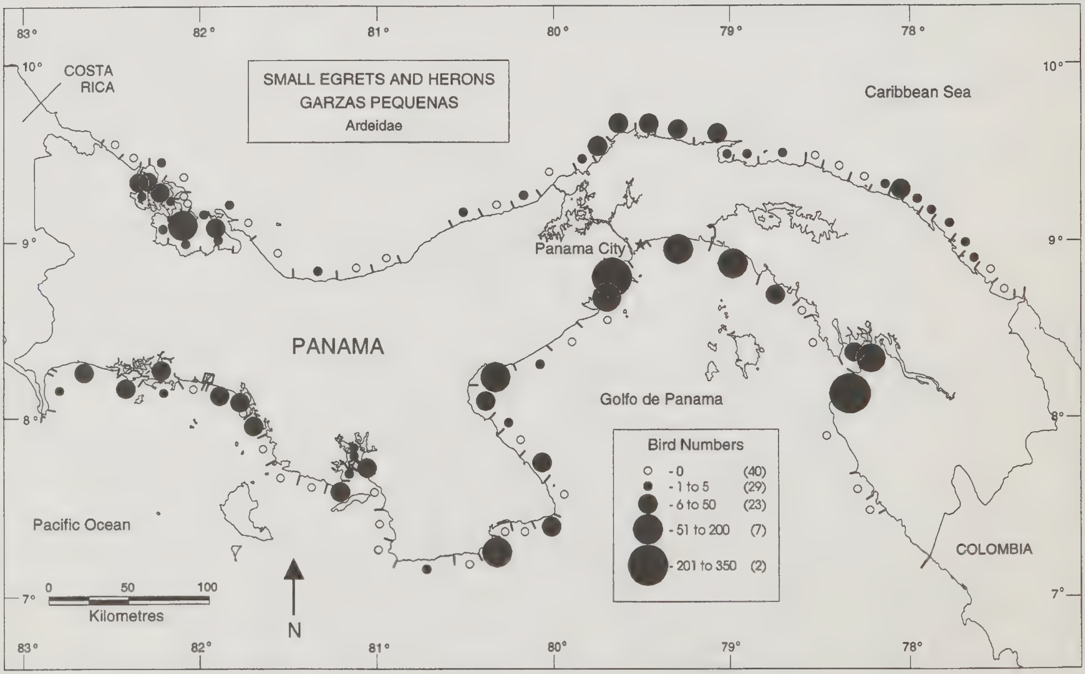

**Map 6.8**
Distribution of Great Egrets *Ardea alba* on the coast of Panama during aerial surveys in January 1993



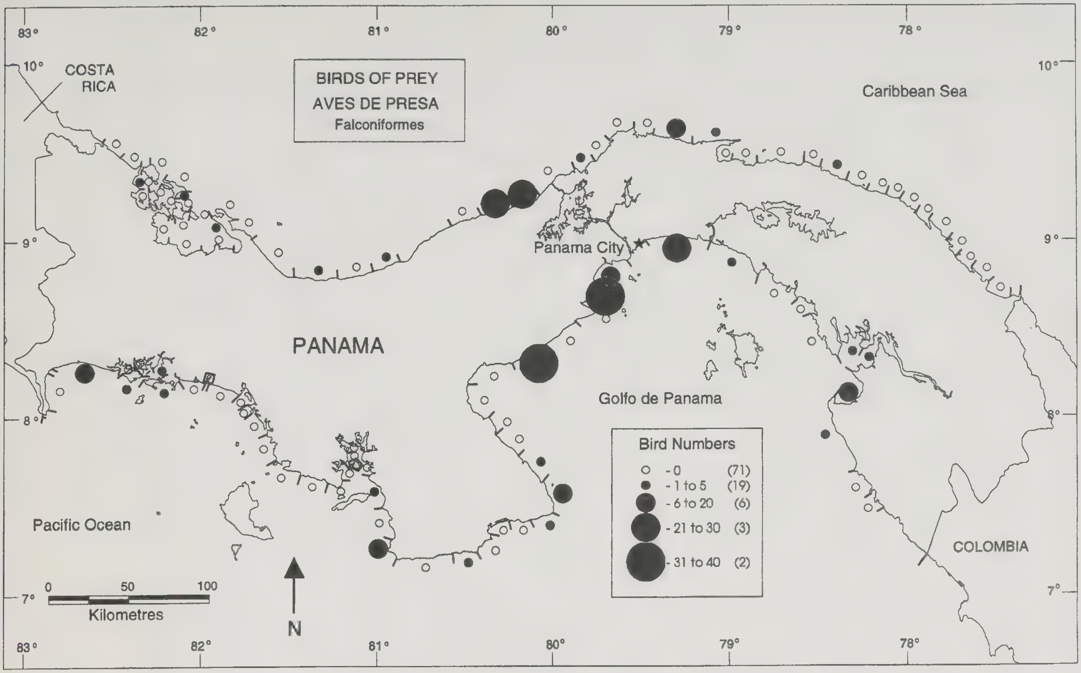
**Map 6.9**
Distribution of Great Blue Herons *Ardea herodias* on the coast of Panama during aerial surveys in January 1993




**Map 6.10**
Distribution of small egrets and herons on the coast of Panama during aerial surveys in January 1993



**Map 6.11**
Distribution of birds of prey on the coast of Panama during aerial surveys in January 1993




**Map 6.12**
Distribution of Ospreys *Pandion haliaetus* on the coast of Panama during aerial surveys in January 1993

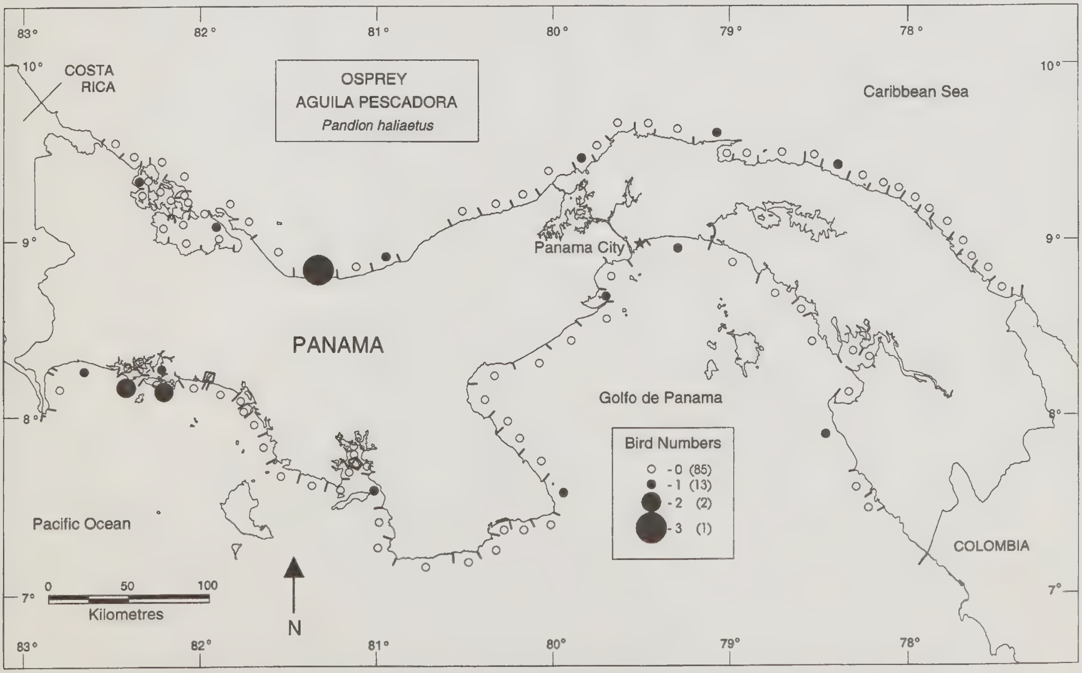


**Table 6.1**
Totals of coastal seabirds, wading birds, birds of prey, and unidentified coastal waterbirds counted during aerial surveys of the coast of Panama in January 1993

**Table 6.1** *(cont'd)*
Totals of coastal seabirds, wading birds, birds of prey, and unidentified coastal waterbirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Coastal seabirds | Wading birds | Birds of prey | Other | Total |
|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | |
| 1 | 16.5 | 8 | 0 | 0 | 0 | 8 |
| 2 | 15.8 | 161 | 0 | 0 | 0 | 161 |
| 3 | 23.9 | 0 | 3 | 0 | 0 | 3 |
| 4 | 19.1 | 6 | 0 | 0 | 0 | 6 |
| 5 | 10.8 | 18 | 0 | 1 | 0 | 19 |
| 6 | 16.7 | 4 | 0 | 0 | 0 | 4 |
| 7 | 17.5 | 43 | 1 | 0 | 0 | 44 |
| 8 | 18.5 | 38 | 51 | 0 | 0 | 89 |
| 9 | 37.6 | 11 | 7 | 0 | 0 | 18 |
| 10 | 17.5 | 25 | 25 | 0 | 0 | 50 |
| 11 | 19.6 | 35 | 12 | 1 | 0 | 48 |
| 12 | 44.4 | 28 | 1 | 0 | 0 | 29 |
| 13 | 44.6 | 40 | 7 | 0 | 0 | 47 |
| 14 | 48.6 | 31 | 4 | 0 | 0 | 35 |
| 15 | 26.0 | 7 | 5 | 0 | 0 | 12 |
| 16 | 32.1 | 323 | 3 | 0 | 30 | 356 |
| 17 | 39.4 | 126 | 14 | 1 | 21 | 162 |
| 18 | 32.6 | 55 | 1 | 0 | 0 | 56 |
| 19 | 26.4 | 10 | 1 | 0 | 0 | 11 |
| 20 | 39.0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 30.2 | 20 | 1 | 3 | 0 | 24 |
| 22 | 21.6 | 14 | 0 | 0 | 0 | 14 |
| 23 | 21.1 | 1 | 0 | 1 | 0 | 2 |
| 24 | n.s. | | | | | |
| 25 | 21.9 | 0 | 2 | 0 | 0 | 2 |
| 26 | 20.9 | 10 | 0 | 21 | 0 | 31 |
| 27 | 22.5 | 25 | 5 | 26 | 0 | 56 |
| 28 | 54.1 | 78 | 1 | 0 | 0 | 79 |
| 29 | 28.7 | 36 | 10 | 1 | 0 | 47 |
| 30 | 18.4 | 17 | 23 | 0 | 0 | 40 |
| 31 | 22.4 | 4 | 10 | 0 | 0 | 14 |
| 32 | 25.5 | 65 | 30 | 0 | 0 | 95 |
| 33 | 29.5 | 3 | 66 | 5 | 0 | 74 |
| 34 | 30.1 | 6 | 70 | 3 | 0 | 79 |
| 35 | 37.4 | 13 | 3 | 0 | 0 | 16 |
| 36 | 21.9 | 0 | 2 | 0 | 0 | 2 |
| 37 | 40.5 | 2 | 2 | 0 | 0 | 4 |
| 38 | 11.8 | 1 | 2 | 0 | 0 | 3 |
| 39 | 23.0 | 5 | 0 | 1 | 0 | 6 |
| 40 | 15.1 | 4 | 1 | 0 | 0 | 5 |
| 41 | 14.3 | 1 | 4 | 0 | 0 | 5 |
| 42 | 12.2 | 0 | 6 | 0 | 2 | 8 |
| 43 | 15.6 | 0 | 3 | 0 | 0 | 3 |
| 44 | 25.9 | 12 | 3 | 0 | 0 | 15 |
| 45 | 22.3 | 1 | 3 | 0 | 0 | 4 |
| 46 | 24.3 | 0 | 1 | 0 | 0 | 1 |
| 47 | 19.8 | 0 | 1 | 0 | 0 | 1 |
| 48 | 21.0 | 7 | 0 | 0 | 0 | 7 |
| 49 | 21.7 | 63 | 0 | 0 | 0 | 63 |
| 50 | n.s. | | | | | |
| **Pacific coast** | | | | | | |
| 51 | n.s. | | | | | |
| 52 | 30.2 | 0 | 0 | 0 | 0 | 0 |
| 53 | 24.6 | 1 | 0 | 0 | 0 | 1 |
| 54 | 58.0 | 80 | 0 | 2 | 0 | 82 |
| 55 | 45.3 | 1 054 | 411 | 12 | 0 | 1 477 |
| 56 | 57.7 | 24 | 120 | 2 | 0 | 146 |
| 57 | 59.4 | 209 | 38 | 3 | 0 | 250 |
| 58 | 48.2 | 817 | 0 | 0 | 0 | 817 |
| 59 | 38.0 | 212 | 0 | 0 | 0 | 212 |
| 60 | 48.5 | 461 | 59 | 0 | 0 | 520 |
| 61 | 40.1 | 1 789 | 111 | 2 | 0 | 1 902 |
| 62 | 44.2 | 1 678 | 252 | 28 | 0 | 1 958 |
| 63 | n.s. | | | | | |
| 64 | 30.9 | 349 | 274 | 11 | 40 | 674 |
| 65 | 40.7 | 946 | 120 | 38 | 0 | 1 104 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 39 | 3 | 0 | 0 | 42 |
| 68 | 24.6 | 4 895 | 4 | 30 | 0 | 4 929 |
| 69 | 37.4 | 4 347 | 76 | 0 | 0 | 4 423 |
| 70 | 31.9 | 880 | 55 | 0 | 0 | 935 |
| 71 | 12.3 | 49 | 4 | 0 | 0 | 53 |
| 72 | 24.9 | 49 | 0 | 0 | 0 | 49 |
| 73 | 21.9 | 44 | 33 | 2 | 0 | 79 |
| 74 | 22.6 | 233 | 0 | 8 | 0 | 241 |
| 75 | 15.9 | 1 | 14 | 1 | 0 | 16 |
| 76 | 26.5 | 500 | 0 | 0 | 0 | 500 |
| 77 | 18.2 | 44 | 5 | 0 | 0 | 49 |
| 78 | 19.3 | 2 | 50 | 0 | 0 | 52 |
| 79 | 21.3 | 71 | 3 | 1 | 0 | 75 |
| 80 | 33.9 | 6 | 3 | 0 | 0 | 9 |
| 81 | 18.8 | 19 | 5 | 5 | 0 | 29 |
| 82 | 31.7 | 21 | 0 | 0 | 0 | 21 |
| 83 | 27.1 | 28 | 9 | 1 | 0 | 38 |
| 84 | 33.2 | 7 | 7 | 0 | 0 | 14 |
| 85 | 36.6 | 22 | 4 | 0 | 0 | 26 |
| 86 | 8.6 | 0 | 2 | 0 | 0 | 2 |
| 87 | 18.0 | 19 | 1 | 0 | 0 | 20 |
| 88 | 19.5 | 14 | 1 | 0 | 0 | 15 |
| 89 | 13.5 | 466 | 15 | 0 | 0 | 481 |
| 90 | 23.6 | 6 | 0 | 0 | 0 | 6 |
| 91 | 41.4 | 16 | 0 | 0 | 0 | 16 |
| 92 | 33.9 | 57 | 0 | 0 | 0 | 57 |
| 93 | 45.0 | 10 | 29 | 0 | 0 | 39 |
| 94 | 7.1 | 3 | 1 | 0 | 0 | 4 |
| 95 | 31.7 | 2 | 21 | 0 | 0 | 23 |
| 96 | 35.2 | 646 | 7 | 0 | 0 | 653 |
| 97 | 18.4 | 342 | 0 | 0 | 0 | 342 |
| 98 | 18.7 | 1 | 0 | 0 | 0 | 1 |
| 99 | 51.9 | 82 | 1 | 4 | 0 | 87 |
| 100 | 52.8 | 113 | 33 | 1 | 0 | 147 |
| 101 | 51.5 | 10 | 0 | 0 | 0 | 10 |
| 102 | 25.0 | 88 | 13 | 2 | 0 | 103 |
| 103 | 26.9 | 316 | 1 | 0 | 0 | 317 |
| 104 | 44.4 | 935 | 9 | 17 | 0 | 961 |
| 105 | n.s. | | | | | |
| 106 | 22.4 | 30 | 4 | 0 | 0 | 34 |
| 107 | n.s. | | | | | |
| 1–50 | 1 220.3 | 1 357 | 384 | 64 | 53 | 1 858 |
| 51–107 | 1 668.1 | 22 033 | 1 798 | 170 | 40 | 20 041 |
| 1–107 | 2 888.4 | 23 390 | 2 182 | 234 | 93 | 25 899 |

n.s. = not surveyed

*Continued*

**Table 6.2**
Totals of coastal seabirds counted during aerial surveys of the coast of Panama in January 1993[a]

| Sector | Sector length (km) | Gulls | Terns | Large terns | Brown Pelican | Neotropic Cormorant | Magnificent Frigatebird | Brown Booby | Red-billed Tropicbird | Coastal seabirds total |
|---|---|---|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | | | | |
| 1 | 16.5 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 2 | 15.8 | 0 | 0 | 0 | 0 | 0 | 1 | 60 | 100 | 161 |
| 3 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 19.1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 |
| 5 | 10.8 | 0 | 0 | 0 | 17 | 0 | 1 | 0 | 0 | 18 |
| 6 | 16.7 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 |
| 7 | 17.5 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 | 43 |
| 8 | 18.5 | 0 | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 38 |
| 9 | 37.6 | 0 | 10 | 0 | 0 | 0 | 1 | 0 | 0 | 11 |
| 10 | 17.5 | 0 | 15 | 0 | 10 | 0 | 0 | 0 | 0 | 25 |
| 11 | 19.6 | 0 | 2 | 0 | 32 | 0 | 1 | 0 | 0 | 35 |
| 12 | 44.4 | 0 | 25 | 0 | 3 | 0 | 0 | 0 | 0 | 28 |
| 13 | 44.6 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 40 |
| 14 | 48.6 | 0 | 0 | 13 | 15 | 2 | 1 | 0 | 0 | 31 |
| 15 | 26.0 | 1 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 7 |
| 16 | 32.1 | 0 | 291 | 0 | 32 | 0 | 0 | 0 | 0 | 323 |
| 17 | 39.4 | 0 | 84 | 0 | 42 | 0 | 0 | 0 | 0 | 126 |
| 18 | 32.6 | 0 | 1 | 0 | 53 | 1 | 0 | 0 | 0 | 55 |
| 19 | 26.4 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 10 |
| 20 | 39.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 30.2 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| 22 | 21.6 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 14 |
| 23 | 21.1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 24 | n.s. | | | | | | | | | |
| 25 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 20.9 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 27 | 22.5 | 5 | 6 | 0 | 13 | 0 | 1 | 0 | 0 | 25 |
| 28 | 54.1 | 2 | 30 | 0 | 45 | 0 | 1 | 0 | 0 | 78 |
| 29 | 28.7 | 1 | 25 | 2 | 8 | 0 | 0 | 0 | 0 | 36 |
| 30 | 18.4 | 0 | 1 | 0 | 16 | 0 | 0 | 0 | 0 | 17 |
| 31 | 22.4 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 |
| 32 | 25.5 | 30 | 0 | 30 | 4 | 1 | 0 | 0 | 0 | 65 |
| 33 | 29.5 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 |
| 34 | 30.1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 |
| 35 | 37.4 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 13 |
| 36 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 40.5 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| 38 | 11.8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 39 | 23.0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 5 |
| 40 | 15.1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 |
| 41 | 14.3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 42 | 12.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | 15.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 44 | 25.9 | 0 | 10 | 0 | 2 | 0 | 0 | 0 | 0 | 12 |
| 45 | 22.3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 46 | 24.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 47 | 19.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 48 | 21.0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 7 |
| 49 | 21.7 | 0 | 0 | 0 | 61 | 0 | 2 | 0 | 0 | 63 |
| 50 | n.s. | | | | | | | | | |
| **Pacific coast** | | | | | | | | | | |
| 51 | n.s. | | | | | | | | | |
| 52 | 30.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 53 | 24.6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 54 | 58.0 | 11 | 0 | 0 | 65 | 0 | 4 | 0 | 0 | 80 |
| 55 | 45.3 | 890 | 100 | 0 | 20 | 33 | 11 | 0 | 0 | 1 054 |
| 56 | 57.7 | 0 | 0 | 0 | 0 | 23 | 1 | 0 | 0 | 24 |
| 57 | 59.4 | 60 | 0 | 0 | 100 | 44 | 5 | 0 | 0 | 209 |

*Continued*

**Table 6.2** *(cont'd)*
Totals of coastal seabirds counted during aerial surveys of the coast of Panama in January 1993[a]

| Sector | Sector length (km) | Gulls | Terns | Large terns | Brown Pelican | Neotropic Cormorant | Magnificent Frigatebird | Brown Booby | Red-billed Tropicbird | Coastal seabirds total |
|---|---|---|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 801 | 0 | 0 | 1 | 10 | 5 | 0 | 0 | 817 |
| 59 | 38.0 | 202 | 0 | 0 | 1 | 1 | 8 | 0 | 0 | 212 |
| 60 | 48.5 | 300 | 110 | 2 | 30 | 1 | 18 | 0 | 0 | 461 |
| 61 | 40.1 | 350 | 991 | 0 | 67 | 170 | 211 | 0 | 0 | 1 789 |
| 62 | 44.2 | 1 190 | 66 | 0 | 324 | 81 | 17 | 0 | 0 | 1 678 |
| 63 | n.s. | | | | | | | | | |
| 64 | 30.9 | 69 | 6 | 4 | 224 | 25 | 21 | 0 | 0 | 349 |
| 65 | 40.7 | 122 | 7 | 0 | 520 | 258 | 39 | 0 | 0 | 946 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 35 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 39 |
| 68 | 24.6 | 3 992 | 831 | 0 | 60 | 0 | 12 | 0 | 0 | 4 895 |
| 69 | 37.4 | 304 | 365 | 0 | 381 | 3 | 0 | 0 | 0 | 4 347 |
| 70 | 31.9 | 727 | 143 | 0 | 4 | 6 | 0 | 0 | 0 | 880 |
| 71 | 12.3 | 47 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 49 |
| 72 | 24.9 | 0 | 20 | 2 | 20 | 2 | 5 | 0 | 0 | 49 |
| 73 | 21.9 | 0 | 35 | 0 | 0 | 1 | 8 | 0 | 0 | 44 |
| 74 | 22.6 | 89 | 50 | 0 | 91 | 0 | 3 | 0 | 0 | 233 |
| 75 | 15.9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 76 | 26.5 | 200 | 0 | 0 | 300 | 0 | 0 | 0 | 0 | 500 |
| 77 | 18.2 | 32 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 44 |
| 78 | 19.3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| 79 | 21.3 | 41 | 20 | 0 | 10 | 0 | 0 | 0 | 0 | 71 |
| 80 | 33.9 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 6 |
| 81 | 18.8 | 0 | 0 | 0 | 17 | 0 | 2 | 0 | 0 | 19 |
| 82 | 31.7 | 14 | 4 | 0 | 1 | 0 | 2 | 0 | 0 | 21 |
| 83 | 27.1 | 20 | 2 | 1 | 5 | 0 | 0 | 0 | 0 | 28 |
| 84 | 33.2 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 85 | 36.6 | 1 | 19 | 0 | 1 | 0 | 1 | 0 | 0 | 22 |
| 86 | 8.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 87 | 18.0 | 0 | 10 | 0 | 7 | 0 | 2 | 0 | 0 | 19 |
| 88 | 19.5 | 0 | 3 | 0 | 11 | 0 | 0 | 0 | 0 | 14 |
| 89 | 13.5 | 60 | 400 | 0 | 6 | 0 | 0 | 0 | 0 | 466 |
| 90 | 23.6 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 |
| 91 | 41.4 | 0 | 6 | 0 | 10 | 0 | 0 | 0 | 0 | 16 |
| 92 | 33.9 | 0 | 0 | 0 | 57 | 0 | 0 | 0 | 0 | 57 |
| 93 | 45.0 | 1 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 10 |
| 94 | 7.1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 |
| 95 | 31.7 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| 96 | 35.2 | 116 | 500 | 0 | 30 | 0 | 0 | 0 | 0 | 646 |
| 97 | 18.4 | 280 | 60 | 0 | 1 | 0 | 1 | 0 | 0 | 342 |
| 98 | 18.7 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 99 | 51.9 | 4 | 0 | 0 | 75 | 0 | 3 | 0 | 0 | 82 |
| 100 | 52.8 | 0 | 24 | 0 | 77 | 0 | 12 | 0 | 0 | 113 |
| 101 | 51.5 | 0 | 2 | 0 | 3 | 0 | 5 | 0 | 0 | 10 |
| 102 | 25.0 | 0 | 0 | 0 | 88 | 0 | 0 | 0 | 0 | 88 |
| 103 | 26.9 | 50 | 263 | 0 | 2 | 0 | 1 | 0 | 0 | 316 |
| 104 | 44.4 | 240 | 322 | 0 | 362 | 0 | 11 | 0 | 0 | 935 |
| 105 | n.s. | | | | | | | | | |
| 106 | 22.4 | 7 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 30 |
| 107 | n.s. | | | | | | | | | |
| 1–50 | 1 220.3 | 39 | 518 | 45 | 582 | 4 | 9 | 60 | 100 | 1 357 |
| 51–107 | 1 668.1 | 991 | 301 | 11 | 3 017 | 658 | 413 | 0 | 100 | 22 033 |
| 1–107 | 2 888.4 | 1 030 | 819 | 56 | 3 599 | 662 | 422 | 60 | 100 | 23 390 |

n.s. = not surveyed

[a] See Table 2.2 for a list of species belonging to each species group.

**Table 6.3**
Totals of wading birds counted during aerial surveys of the coast of Panama in January 1993[a]

| Sector | Sector length (km) | Egret: small white | White Ibis | Great Blue Heron | Little Blue Heron | Great Egret | Night-Heron | Wading birds total |
|---|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | | |
| 1 | 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 15.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 23.9 | 2 | 0 | 1 | 0 | 0 | 0 | 3 |
| 4 | 19.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 10.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 16.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 17.5 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 8 | 18.5 | 50 | 0 | 1 | 0 | 0 | 0 | 51 |
| 9 | 37.6 | 3 | 0 | 4 | 0 | 0 | 0 | 7 |
| 10 | 17.5 | 25 | 0 | 0 | 0 | 0 | 0 | 25 |
| 11 | 19.6 | 8 | 0 | 4 | 0 | 0 | 0 | 12 |
| 12 | 44.4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 13 | 44.6 | 5 | 0 | 1 | 1 | 0 | 0 | 7 |
| 14 | 48.6 | 2 | 0 | 1 | 0 | 1 | 0 | 4 |
| 15 | 26.0 | 1 | 0 | 4 | 0 | 0 | 0 | 5 |
| 16 | 32.1 | 1 | 0 | 1 | 0 | 1 | 0 | 3 |
| 17 | 39.4 | 11 | 0 | 2 | 0 | 1 | 0 | 14 |
| 18 | 32.6 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 19 | 26.4 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 20 | 39.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 30.2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 22 | 21.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 21.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | n.s. | | | | | | | |
| 25 | 21.9 | 1 | 0 | 0 | 1 | 0 | 0 | 2 |
| 26 | 20.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 22.5 | 3 | 0 | 0 | 1 | 1 | 0 | 5 |
| 28 | 54.1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 29 | 28.7 | 2 | 0 | 4 | 2 | 2 | 0 | 10 |
| 30 | 18.4 | 10 | 0 | 2 | 2 | 9 | 0 | 23 |
| 31 | 22.4 | 2 | 0 | 3 | 3 | 2 | 0 | 10 |
| 32 | 25.5 | 11 | 0 | 2 | 2 | 15 | 0 | 30 |
| 33 | 29.5 | 23 | 0 | 4 | 5 | 34 | 0 | 66 |
| 34 | 30.1 | 23 | 0 | 12 | 7 | 27 | 1 | 70 |
| 35 | 37.4 | 1 | 0 | 2 | 0 | 0 | 0 | 3 |
| 36 | 21.9 | 1 | 0 | 0 | 1 | 0 | 0 | 2 |
| 37 | 40.5 | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| 38 | 11.8 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| 39 | 23.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 15.1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 41 | 14.3 | 1 | 0 | 2 | 0 | 1 | 0 | 4 |
| 42 | 12.2 | 5 | 0 | 0 | 0 | 1 | 0 | 6 |
| 43 | 15.6 | 2 | 0 | 1 | 0 | 0 | 0 | 3 |
| 44 | 25.9 | 1 | 0 | 1 | 0 | 1 | 0 | 3 |
| 45 | 22.3 | 1 | 0 | 0 | 1 | 1 | 0 | 3 |
| 46 | 24.3 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 47 | 19.8 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 48 | 21.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49 | 21.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | n.s. | | | | | | | |
| **Pacific coast** | | | | | | | | |
| 51 | n.s. | | | | | | | |
| 52 | 30.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 53 | 24.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 54 | 58.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 55 | 45.3 | 305 | 104 | 2 | 0 | 0 | 0 | 411 |
| 56 | 57.7 | 116 | 0 | 4 | 0 | 0 | 0 | 120 |
| 57 | 59.4 | 38 | 0 | 0 | 0 | 0 | 0 | 38 |

*Continued*

**Table 6.3** *(cont'd)*
Totals of wading birds counted during aerial surveys of the coast of Panama in January 1993[a]

| Sector | Sector length (km) | Egret: small white | White Ibis | Great Blue Heron | Little Blue Heron | Great Egret | Night-Heron | Wading birds total |
|---|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 48.5 | 31 | 0 | 28 | 0 | 0 | 0 | 59 |
| 61 | 40.1 | 100 | 0 | 8 | 2 | 1 | 0 | 111 |
| 62 | 44.2 | 100 | 50 | 2 | 0 | 100 | 0 | 252 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 271 | 0 | 3 | 0 | 0 | 0 | 274 |
| 65 | 40.7 | 105 | 0 | 12 | 1 | 2 | 0 | 120 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 0 | 0 | 2 | 0 | 1 | 0 | 3 |
| 68 | 24.6 | 3 | 0 | 1 | 0 | 0 | 0 | 4 |
| 69 | 37.4 | 65 | 0 | 8 | 0 | 3 | 0 | 76 |
| 70 | 31.9 | 43 | 0 | 1 | 0 | 11 | 0 | 55 |
| 71 | 12.3 | 0 | 0 | 3 | 1 | 0 | 0 | 4 |
| 72 | 24.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73 | 21.9 | 31 | 0 | 0 | 0 | 2 | 0 | 33 |
| 74 | 22.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 75 | 15.9 | 12 | 0 | 2 | 0 | 0 | 0 | 14 |
| 76 | 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 77 | 18.2 | 0 | 5 | 0 | 0 | 0 | 0 | 5 |
| 78 | 19.3 | 50 | 0 | 0 | 0 | 0 | 0 | 50 |
| 79 | 21.3 | 0 | 0 | 2 | 0 | 1 | 0 | 3 |
| 80 | 33.9 | 3 | 0 | 0 | 0 | 0 | 0 | 3 |
| 81 | 18.8 | 0 | 0 | 5 | 0 | 0 | 0 | 5 |
| 82 | 31.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 83 | 27.1 | 0 | 0 | 3 | 0 | 6 | 0 | 9 |
| 84 | 33.2 | 5 | 0 | 0 | 0 | 2 | 0 | 7 |
| 85 | 36.6 | 4 | 0 | 0 | 0 | 0 | 0 | 4 |
| 86 | 8.6 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| 87 | 18.0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 88 | 19.5 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 89 | 13.5 | 14 | 0 | 0 | 0 | 1 | 0 | 15 |
| 90 | 23.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 41.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 92 | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 93 | 45.0 | 27 | 0 | 0 | 0 | 2 | 0 | 29 |
| 94 | 7.1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 95 | 31.7 | 6 | 0 | 0 | 15 | 0 | 0 | 21 |
| 96 | 35.2 | 7 | 0 | 0 | 0 | 0 | 0 | 7 |
| 97 | 18.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 98 | 18.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 99 | 51.9 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 100 | 52.8 | 33 | 0 | 0 | 0 | 0 | 0 | 33 |
| 101 | 51.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 102 | 25.0 | 10 | 0 | 2 | 1 | 0 | 0 | 13 |
| 103 | 26.9 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 104 | 44.4 | 7 | 0 | 0 | 0 | 2 | 0 | 9 |
| 105 | n.s. | | | | | | | |
| 106 | 22.4 | 2 | 0 | 2 | 0 | 0 | 0 | 4 |
| 107 | n.s. | | | | | | | |
| 1–50 | 1220.3 | 201 | 0 | 57 | 27 | 98 | 1 | 384 |
| 51–107 | 1668.1 | 1392 | 159 | 90 | 20 | 137 | 0 | 1798 |
| 1–107 | 2888.4 | 1593 | 159 | 147 | 47 | 235 | 1 | 2182 |

n.s. = not surveyed

[a] See Table 2.2 for a list of species belonging to each species group.

**Table 6.4**
Totals of birds of prey and unidentified coastal waterbirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Osprey | Black Vulture | Crested Caracara | Peregrine Falcon | Unidentified birds of prey | Birds of prey total | Other unidentified waterbirds |
|---|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | | |
| 1 | 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 15.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 19.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 10.8 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 6 | 16.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 37.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 19.6 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 12 | 44.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 44.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 48.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 26.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 32.1 | 0 | 0 | 0 | 0 | 0 | 0 | 30 |
| 17 | 39.4 | 1 | 0 | 0 | 0 | 0 | 1 | 21 |
| 18 | 32.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 26.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 39.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 30.2 | 3 | 0 | 0 | 0 | 0 | 3 | 0 |
| 22 | 21.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 21.1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 24 | n.s. | | | | | | | |
| 25 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 20.9 | 0 | 21 | 0 | 0 | 0 | 21 | 0 |
| 27 | 22.5 | 0 | 26 | 0 | 0 | 0 | 26 | 0 |
| 28 | 54.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 28.7 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 30 | 18.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 22.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | 29.5 | 0 | 4 | 1 | 0 | 0 | 5 | 0 |
| 34 | 30.1 | 1 | 2 | 0 | 0 | 0 | 3 | 0 |
| 35 | 37.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 21.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 40.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 11.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | 23.0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 40 | 15.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | 14.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42 | 12.2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 43 | 15.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 44 | 25.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 45 | 22.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46 | 24.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 47 | 19.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 48 | 21.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49 | 21.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | n.s. | | | | | | | |
| **Pacific coast** | | | | | | | | |
| 51 | n.s. | | | | | | | |
| 52 | 30.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 53 | 24.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 54 | 58.0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 |
| 55 | 45.3 | 0 | 12 | 0 | 0 | 0 | 12 | 0 |
| 56 | 57.7 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| 57 | 59.4 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |

*Continued*

**Table 6.4** *(cont'd)*
Totals of birds of prey and unidentified coastal waterbirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Osprey | Black Vulture | Crested Caracara | Peregrine Falcon | Uniden-tified birds of prey | Birds of prey total | Other unidentified waterbirds |
|---|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 48.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 61 | 40.1 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| 62 | 44.2 | 1 | 25 | 0 | 0 | 2 | 28 | 0 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 11 | 0 | 0 | 0 | 11 | 40 |
| 65 | 40.7 | 1 | 36 | 0 | 0 | 1 | 38 | 0 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 30 | 0 | 0 | 0 | 30 | 0 |
| 69 | 37.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 31.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 72 | 24.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73 | 21.9 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| 74 | 22.6 | 1 | 7 | 0 | 0 | 0 | 8 | 0 |
| 75 | 15.9 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 76 | 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 77 | 18.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 78 | 19.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 79 | 21.3 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 80 | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81 | 18.8 | 0 | 5 | 0 | 0 | 0 | 5 | 0 |
| 82 | 31.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 83 | 27.1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 84 | 33.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 85 | 36.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 86 | 8.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 87 | 18.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 88 | 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 89 | 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 23.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 41.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 92 | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 93 | 45.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 94 | 7.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 95 | 31.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 96 | 35.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 97 | 18.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 98 | 18.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 99 | 51.9 | 2 | 2 | 0 | 0 | 0 | 4 | 0 |
| 100 | 52.8 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 101 | 51.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 102 | 25.0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 |
| 103 | 26.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 104 | 44.4 | 1 | 15 | 1 | 0 | 0 | 17 | 0 |
| 105 | n.s. | | | | | | | |
| 106 | 22.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 107 | n.s. | | | | | | | |
| 1–50 | 1220.3 | 9 | 53 | 1 | 1 | 0 | 53 | 64 |
| 51–107 | 1668.1 | 11 | 150 | 4 | 4 | 1 | 40 | 170 |
| 1–107 | 2888.4 | 20 | 203 | 5 | 1 | 5 | 234 | 93 |

n.s. = not surveyed

**Table 6.5**
Numbers of nests censused in colonies of waterbirds at Parita in 1977 and at Chitre in 1985 (FSD, unpubl. data)

| | No. of nesting pairs | |
|---|---|---|
| Species | Parita | Chitre |
| Great Egret | 377 | 15 |
| Snowy Egret | 0 | 10 |
| Tricolored Heron | 5 | 21 |
| Cattle Egret | 1603 | 3864 |
| Green Heron | 4 | 0 |
| Black-crowned Night-Heron | 6 | 145 |
| Boat-billed Heron | 22 | 5 |
| White Ibis | 83 | 7 |
| Anhinga | 45 | 3 |

**Table 6.6**
Summary of totals of coastal seabirds, wading birds, birds of prey, and other species counted in the Golfo de Panama in February 1988, October 1991, and January 1993

| | Coastal seabirds | Wading birds | Birds of prey | Other species | Total |
|---|---|---|---|---|---|
| February 1988 | 20 059 | 1 829 | 78 | 2 000 | 23 966 |
| October 1991 | 14 385 | 971 | 249 | 0 | 15 605 |
| January 1993 | 17 749 | 1 527 | 126 | 40 | 19 442 |

**Table 6.7**
Totals of coastal seabirds, wading birds, birds of prey, and other birds counted during aerial surveys of the coast of the Golfo de Panama in February 1988, October 1991, and January 1993

| Sector | Sector length (km) | Coastal seabirds | Wading birds | Birds of prey | Other | Total |
|---|---|---|---|---|---|---|
| **February 1988** | | | | | | |
| 55 | 45.3 | 184 | 186 | 4 | 0 | 374 |
| 56 | 57.7 | 82 | 74 | 0 | 0 | 156 |
| 57 | 59.4 | 97 | 121 | 1 | 0 | 219 |
| 58 | 48.2 | 194 | 2 | 0 | 0 | 196 |
| 59 | 38.0 | 203 | 27 | 0 | 0 | 230 |
| 60 | 48.5 | 906 | 101 | 5 | 0 | 1 012 |
| 61 | 40.1 | 6 553 | 785 | 4 | 0 | 7 342 |
| 62 | 44.2 | 6 101 | 148 | 3 | 2 000 | 8 252 |
| 63 | n.s. | | | | | |
| 64 | 30.9 | 275 | 185 | 1 | 0 | 461 |
| 65 | 40.7 | 334 | 105 | 55 | 0 | 494 |
| 66 | 30.8 | 526 | 0 | 2 | 0 | 528 |
| 67 | 23.9 | 618 | 0 | 0 | 0 | 618 |
| 68 | 24.6 | 287 | 0 | 1 | 0 | 288 |
| 69 | 37.4 | 2 546 | 45 | 1 | 0 | 2 592 |
| 70 | 31.9 | 1 153 | 45 | 1 | 0 | 1 199 |
| 71 | 12.3 | 0 | 5 | 0 | 0 | 5 |
| | 661.6 | 20 059 | 1 829 | 78 | 2 000 | 23 966 |
| **October 1991** | | | | | | |
| 55 | 45.3 | 991 | 5 | 0 | 0 | 996 |
| 56 | 57.7 | 192 | 65 | 1 | 0 | 258 |
| 57 | 59.4 | 164 | 265 | 2 | 0 | 431 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 5 | 1 | 0 | 0 | 6 |
| 60 | 48.5 | 1 194 | 1 | 0 | 0 | 1 195 |
| 61 | 40.1 | 3 411 | 122 | 10 | 0 | 3 543 |
| 62 | 44.2 | 2 425 | 13 | 5 | 0 | 2 443 |
| 63 | n.s. | | | | | |
| 64 | 30.9 | 341 | 101 | 52 | 0 | 494 |
| 65 | 40.7 | 159 | 62 | 61 | 0 | 282 |
| 66 | 30.8 | 868 | 30 | 0 | 0 | 898 |
| 67 | 23.9 | 29 | 4 | 9 | 0 | 42 |
| 68 | 24.6 | 1 425 | 19 | 81 | 0 | 1 525 |
| 69 | 37.4 | 2 248 | 34 | 4 | 0 | 2 286 |
| 70 | 31.9 | 933 | 249 | 24 | 0 | 1 206 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 |
| | 661.6 | 14 385 | 971 | 249 | 0 | 15 605 |
| **January 1993** | | | | | | |
| 55 | 45.3 | 1 054 | 411 | 12 | 0 | 1 477 |
| 56 | 57.7 | 24 | 120 | 2 | 0 | 146 |
| 57 | 59.4 | 209 | 38 | 3 | 0 | 250 |
| 58 | 48.2 | 817 | 0 | 0 | 0 | 817 |
| 59 | 38.0 | 212 | 0 | 0 | 0 | 212 |
| 60 | 48.5 | 461 | 59 | 0 | 0 | 520 |
| 61 | 40.1 | 1 789 | 111 | 2 | 0 | 1 902 |
| 62 | 44.2 | 1 678 | 252 | 28 | 0 | 1 958 |
| 63 | n.s. | | | | | |
| 64 | 30.9 | 349 | 274 | 11 | 40 | 674 |
| 65 | 40.7 | 946 | 120 | 38 | 0 | 1 104 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 39 | 3 | 0 | 0 | 42 |
| 68 | 24.6 | 4 895 | 4 | 30 | 0 | 4 929 |
| 69 | 37.4 | 4 347 | 76 | 0 | 0 | 4 423 |
| 70 | 31.9 | 880 | 55 | 0 | 0 | 935 |
| 71 | 12.3 | 49 | 4 | 0 | 0 | 53 |
| | 661.6 | 17 749 | 1 527 | 126 | 40 | 19 442 |

n.s. = not surveyed

**Table 6.8**
Totals of coastal seabirds counted during aerial surveys of the coast of the Golfo de Panama in February 1988, October 1991, and January 1993[a]

| Sector | Sector length (km) | Gulls | Terns | Large terns | Black Skimmer | Brown Pelican | Neotropic Cormorant | Magnificent Frigatebird | Total |
|---|---|---|---|---|---|---|---|---|---|
| **February 1988** | | | | | | | | | |
| 55 | 45.3 | 1 | 135 | 0 | 0 | 35 | 11 | 2 | 184 |
| 56 | 57.7 | 12 | 59 | 0 | 0 | 2 | 9 | 0 | 82 |
| 57 | 59.4 | 18 | 53 | 0 | 0 | 23 | 3 | 0 | 97 |
| 58 | 48.2 | 4 | 54 | 0 | 0 | 130 | 2 | 4 | 194 |
| 59 | 38.0 | 1 | 22 | 0 | 0 | 128 | 21 | 31 | 203 |
| 60 | 48.5 | 257 | 126 | 0 | 0 | 503 | 3 | 17 | 906 |
| 61 | 40.1 | 928 | 1 021 | 0 | 0 | 3 053 | 1 535 | 16 | 6 553 |
| 62 | 44.2 | 431 | 1 730 | 0 | 0 | 600 | 3 340 | 0 | 6 101 |
| 63 | n.s. | | | | | | | | |
| 64 | 30.9 | 102 | 62 | 0 | 0 | 91 | 3 | 17 | 275 |
| 65 | 40.7 | 102 | 100 | 0 | 0 | 69 | 16 | 47 | 334 |
| 66 | 30.8 | 39 | 170 | 0 | 0 | 231 | 36 | 50 | 526 |
| 67 | 23.9 | 105 | 56 | 0 | 0 | 435 | 8 | 14 | 618 |
| 68 | 24.6 | 8 | 54 | 0 | 0 | 139 | 61 | 25 | 287 |
| 69 | 37.4 | 1 700 | 77 | 0 | 0 | 572 | 132 | 65 | 2 546 |
| 70 | 31.9 | 11 | 1 000 | 0 | 0 | 20 | 6 | 116 | 1 153 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 661.6 | 3 719 | 4 719 | 0 | 0 | 6 031 | 5 186 | 404 | 20 059 |
| **October 1991** | | | | | | | | | |
| 55 | 45.3 | 30 | 375 | 70 | 30 | 187 | 249 | 50 | 991 |
| 56 | 57.7 | 0 | 0 | 0 | 0 | 142 | 50 | 0 | 192 |
| 57 | 59.4 | 0 | 0 | 0 | 0 | 10 | 154 | 0 | 164 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 5 |
| 60 | 48.5 | 403 | 100 | 0 | 0 | 558 | 75 | 58 | 1 194 |
| 61 | 40.1 | 610 | 504 | 0 | 0 | 601 | 1 676 | 20 | 3 411 |
| 62 | 44.2 | 170 | 351 | 0 | 0 | 650 | 1 252 | 2 | 2 425 |
| 63 | n.s. | | | | | | | | |
| 64 | 30.9 | 10 | 0 | 0 | 0 | 88 | 151 | 92 | 341 |
| 65 | 40.7 | 8 | 1 | 1 | 0 | 122 | 5 | 22 | 159 |
| 66 | 30.8 | 15 | 1 | 0 | 0 | 825 | 0 | 27 | 868 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 9 | 5 | 15 | 29 |
| 68 | 24.6 | 0 | 0 | 0 | 0 | 440 | 24 | 961 | 1 425 |
| 69 | 37.4 | 1 | 222 | 0 | 0 | 1 840 | 165 | 20 | 2 248 |
| 70 | 31.9 | 150 | 404 | 0 | 0 | 270 | 30 | 79 | 933 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 661.6 | 1 397 | 1 958 | 71 | 30 | 5 747 | 3 836 | 1 346 | 14 385 |
| **January 1993** | | | | | | | | | |
| 55 | 45.3 | 890 | 100 | 0 | 0 | 20 | 33 | 11 | 1 054 |
| 56 | 57.7 | 0 | 0 | 0 | 0 | 0 | 23 | 1 | 24 |
| 57 | 59.4 | 60 | 0 | 0 | 0 | 100 | 44 | 5 | 209 |
| 58 | 48.2 | 801 | 0 | 0 | 0 | 1 | 10 | 5 | 817 |
| 59 | 38.0 | 202 | 0 | 0 | 0 | 1 | 1 | 8 | 212 |
| 60 | 48.5 | 300 | 110 | 2 | 0 | 30 | 1 | 18 | 461 |
| 61 | 40.1 | 350 | 991 | 0 | 0 | 67 | 170 | 211 | 1 789 |
| 62 | 44.2 | 1 190 | 66 | 0 | 0 | 324 | 81 | 17 | 1 678 |
| 63 | n.s. | | | | | | | | |
| 64 | 30.9 | 69 | 6 | 4 | 0 | 224 | 25 | 21 | 349 |
| 65 | 40.7 | 122 | 7 | 0 | 0 | 520 | 258 | 39 | 946 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 35 | 0 | 2 | 0 | 0 | 0 | 2 | 39 |
| 68 | 24.6 | 3 992 | 831 | 0 | 0 | 60 | 0 | 12 | 4 895 |
| 69 | 37.4 | 304 | 3 659 | 0 | 0 | 381 | 3 | 0 | 4 347 |
| 70 | 31.9 | 727 | 143 | 0 | 0 | 4 | 6 | 0 | 880 |
| 71 | 12.3 | 47 | 1 | 0 | 0 | 0 | 0 | 1 | 49 |
| | 661.6 | 9 089 | 5 914 | 8 | 0 | 1 732 | 655 | 351 | 17 749 |

n.s. = not surveyed

[a] See Table 2.2 for a list of species belonging to each species group.

**Table 6.9**
Totals of wading birds counted during aerial surveys of the coast of the Golfo de Panama in February 1988, October 1991, and January 1993[a]

| Sector | Sector length (km) | Wood Stork | Egret: small white[b] | White Ibis | Roseate Spoonbill | Heron: large dark | Little Blue Heron | Heron: large white | Night-Heron | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **February 1988** | | | | | | | | | | |
| 55 | 45.3 | 0 | 170 | 13 | 0 | 2 | 1 | 0 | 0 | 186 |
| 56 | 57.7 | 0 | 47 | 26 | 0 | 0 | 1 | 0 | 0 | 74 |
| 57 | 59.4 | 0 | 116 | 0 | 0 | 4 | 1 | 0 | 0 | 121 |
| 58 | 48.2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 59 | 38.0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| 60 | 48.5 | 0 | 81 | 20 | 0 | 0 | 0 | 0 | 0 | 101 |
| 61 | 40.1 | 0 | 769 | 0 | 0 | 1 | 15 | 0 | 0 | 785 |
| 62 | 44.2 | 0 | 146 | 0 | 0 | 1 | 1 | 0 | 0 | 148 |
| 63 | n.s. | | | | | | | | | |
| 64 | 30.9 | 0 | 175 | 0 | 1 | 7 | 2 | 0 | 0 | 185 |
| 65 | 40.7 | 0 | 105 | 0 | 0 | 0 | 0 | 0 | 0 | 105 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 69 | 37.4 | 0 | 40 | 0 | 0 | 3 | 2 | 0 | 0 | 45 |
| 70 | 31.9 | 0 | 39 | 6 | 0 | 0 | 0 | 0 | 0 | 45 |
| 71 | 12.3 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| | 661.6 | 0 | 1722 | 65 | 1 | 18 | 23 | 0 | 0 | 1829 |
| **October 1991** | | | | | | | | | | |
| 55 | 45.3 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 5 |
| 56 | 57.7 | 0 | 53 | 0 | 0 | 0 | 12 | 0 | 0 | 65 |
| 57 | 59.4 | 0 | 117 | 0 | 0 | 1 | 143 | 4 | 0 | 265 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 60 | 48.5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 61 | 40.1 | 0 | 115 | 0 | 0 | 0 | 7 | 0 | 0 | 122 |
| 62 | 44.2 | 0 | 11 | 0 | 1 | 1 | 0 | 0 | 0 | 13 |
| 63 | n.s. | | | | | | | | | |
| 64 | 30.9 | 0 | 70 | 0 | 8 | 6 | 16 | 1 | 0 | 101 |
| 65 | 40.7 | 0 | 48 | 0 | 7 | 1 | 5 | 1 | 0 | 62 |
| 66 | 30.8 | 0 | 26 | 0 | 0 | 2 | 1 | 1 | 0 | 30 |
| 67 | 23.9 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 68 | 24.6 | 0 | 17 | 0 | 0 | 1 | 1 | 0 | 0 | 19 |
| 69 | 37.4 | 0 | 22 | 0 | 0 | 6 | 2 | 4 | 0 | 34 |
| 70 | 31.9 | 37 | 135 | 0 | 55 | 2 | 2 | 18 | 0 | 249 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 661.6 | 37 | 622 | 0 | 71 | 20 | 192 | 29 | 0 | 971 |
| **January 1993** | | | | | | | | | | |
| 55 | 45.3 | 0 | 305 | 104 | 0 | 2 | 0 | 0 | 0 | 411 |
| 56 | 57.7 | 0 | 116 | 0 | 0 | 4 | 0 | 0 | 0 | 120 |
| 57 | 59.4 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 38 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 48.5 | 0 | 31 | 0 | 0 | 28 | 0 | 0 | 0 | 59 |
| 61 | 40.1 | 0 | 100 | 0 | 0 | 8 | 2 | 1 | 0 | 111 |
| 62 | 44.2 | 0 | 100 | 50 | 0 | 2 | 0 | 100 | 0 | 252 |
| 63 | n.s. | | | | | | | | | |
| 64 | 30.9 | 0 | 271 | 0 | 0 | 3 | 0 | 0 | 0 | 274 |
| 65 | 40.7 | 0 | 105 | 0 | 0 | 12 | 1 | 2 | 0 | 120 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 3 |
| 68 | 24.6 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 4 |
| 69 | 37.4 | 0 | 65 | 0 | 0 | 8 | 0 | 3 | 0 | 76 |
| 70 | 31.9 | 0 | 43 | 0 | 0 | 1 | 0 | 11 | 0 | 55 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 4 |
| | 661.6 | 0 | 1177 | 154 | 0 | 74 | 4 | 118 | 0 | 1527 |

n.s. = not surveyed

[a] See Table 2.2 for a list of species belonging to each species group.
[b] Includes large and small egrets in February 1988.

**Table 6.10**
Totals of birds of prey and other birds counted during aerial surveys of the coast of the Golfo de Panama in February 1988, October 1991, and January 1993

| Sector | Sector length (km) | Osprey | Black Vulture | Crested Caracara | Peregrine Falcon | Unidentified birds of prey | Other birds (ducks) | Total |
|---|---|---|---|---|---|---|---|---|
| **February 1988** | | | | | | | | |
| 55 | 45.3 | 4 | 0 | 0 | 0 | 0 | 0 | 4 |
| 56 | 57.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57 | 59.4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 48.5 | 3 | 2 | 0 | 0 | 0 | 0 | 5 |
| 61 | 40.1 | 2 | 2 | 0 | 0 | 0 | 0 | 4 |
| 62 | 44.2 | 3 | 0 | 0 | 0 | 0 | 2000 | 2003 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 65 | 40.7 | 0 | 55 | 0 | 0 | 0 | 0 | 55 |
| 66 | 30.8 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 69 | 37.4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 70 | 31.9 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 661.6 | 18 | 60 | 0 | 0 | 0 | 2000 | 2078 |
| **October 1991** | | | | | | | | |
| 55 | 45.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 56 | 57.7 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 57 | 59.4 | 1 | 0 | 0 | 0 | 1 | 0 | 2 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 48.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 61 | 40.1 | 0 | 9 | 0 | 0 | 1 | 0 | 10 |
| 62 | 44.2 | 1 | 4 | 0 | 0 | 0 | 0 | 5 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 52 | 0 | 0 | 0 | 0 | 52 |
| 65 | 40.7 | 3 | 58 | 0 | 0 | 0 | 0 | 61 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 0 | 8 | 0 | 1 | 0 | 0 | 9 |
| 68 | 24.6 | 0 | 80 | 1 | 0 | 0 | 0 | 81 |
| 69 | 37.4 | 1 | 0 | 3 | 0 | 0 | 0 | 4 |
| 70 | 31.9 | 1 | 23 | 0 | 0 | 0 | 0 | 24 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 661.6 | 8 | 234 | 4 | 1 | 2 | 0 | 249 |
| **January 1993** | | | | | | | | |
| 55 | 45.3 | 0 | 12 | 0 | 0 | 0 | 0 | 12 |
| 56 | 57.7 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| 57 | 59.4 | 0 | 3 | 0 | 0 | 0 | 0 | 3 |
| 58 | 48.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 38.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 48.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 61 | 40.1 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| 62 | 44.2 | 1 | 25 | 0 | 0 | 2 | 0 | 28 |
| 63 | n.s. | | | | | | | |
| 64 | 30.9 | 0 | 11 | 0 | 0 | 0 | 40 | 51 |
| 65 | 40.7 | 1 | 36 | 0 | 0 | 1 | 0 | 38 |
| 66 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 23.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 68 | 24.6 | 0 | 30 | 0 | 0 | 0 | 0 | 30 |
| 69 | 37.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 31.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 71 | 12.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 661.6 | 2 | 121 | 0 | 0 | 3 | 40 | 166 |

n.s. = not surveyed

# *Chapter 7*
# Distribution of shorebirds, coastal seabirds, and wading birds in relation to oceanic upwelling along the Pacific coast of Panama

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## 7.1 Introduction

The Pacific coast of Panama has extensive mangrove ecosystems that support large numbers of Nearctic shorebirds, as well as Neotropical seabirds and wading birds, and exceptionally high densities occur in the Golfo de Panama (Loftin 1991; Butler et al. 1992; see Chapters 5 and 6). The seasonal oceanic upwelling that occurs in the Golfo de Panama is known to affect the abundance and productivity of a number of marine organisms, including birds (see Chapter 3). Whereas upwelling is pronounced in the Golfo de Panama, it is absent in the western parts of the country in the Golfo de Chiriqui (Kwiecinski and Chial 1983). In terms of habitat use, the greatest densities of coastal birds in Panama occur on mudflats adjacent to mangroves (Butler et al. 1997). This chapter examines the relationship between upwelling and the densities of shorebirds, coastal seabirds, and wading birds in Panama. Our null hypotheses were that there were no differences in densities of shorebirds, coastal seabirds, or wading birds (1) between different coastal habitats within similar areas of upwelling or (2) between the same habitats in different areas of upwelling.

## 7.2 Environmental conditions

The oceanography, geology, and climate of the Panamanian coastline were described in Chapter 3. A relatively dry season occurs from January to April and is accompanied by northeasterly winds, which induce upwelling of cool nutrient-laden waters in the Golfo de Panama (Schaefer et al. 1958; D'Croz et al. 1991). These nutrients create extensive phytoplankton blooms that form the ecological basis of an abundant fishery and attract large numbers of fish-eating birds (Loftin 1991). Upwelling does not occur in western Panama, where wind stress is much reduced (Kwiecinski and Chial 1983). Tropical rainforest predominates along the Pacific coastline of eastern Panama, whereas dry forest and grassland are widespread in western Panama. Mangrove and mudflat ecosystems are found along much of the Pacific coast and are most extensive between Panama City and the Golfo de San Miguel (Delgado 1986). Smaller mangroves and mudflats are found in Bahia de Parita on the western side of the Golfo de Panama, in the Golfo de Montijo, and in inlets along the Golfo de Chiriqui in western Panama (Chapter 4).

## 7.3 Statistical analyses

Surveys conducted over large geographical areas are likely to contain many sectors that do not contain suitable habitat for a particular group of birds and in which that group of birds may be absent (or present in very low concentrations). Data obtained during such surveys will contain many zero values, with the result that the data are likely to be considerably skewed and not normally distributed. Inspection of the data collected on the surveys in Panama (see Chapters 5 and 6) indicated that this situation did indeed occur. Formal testing of the data for normality using methods described by D'Agostino et al. (1990) indicated that none of the data for the major groups were normally distributed, showing departures from normality in both skewness and kurtosis. Logarithmic or square root transformation of the entire data set did not result in the data becoming normally distributed, departures from normality remaining in both skewness and kurtosis.

Non-parametric tests were therefore employed to examine the differences in distribution of the major groups of shorebirds and other coastal waterbirds between different habitat types. Two tests based on ranking procedures, the Wilcoxon test and k-sample median test, were employed using the NPAR1WAY procedure of the SAS statistical package (SAS Institute, Inc. 1988). Differences between the various habitat groups were also examined by computing rank scores, conducting an ANOVA, and comparing mean scores using a Studentized Maximum Modulus (GT2) test (SAS Institute, Inc. 1988). The use of medians resulted in a number of groups of birds having median densities of zero, in cases where that group or species was absent in more than half the sectors of a particular habitat. Mean densities are also presented for comparison.

To investigate the influence of oceanic upwelling, bird densities were compared in a specific habitat category in areas with upwelling and with no upwelling. Sectors considered to be affected by upwelling included those in the Golfo de Panama and eastern parts of the country (Sectors 51–74), and sectors not affected by upwelling included those in the Golfo de Chiriqui and areas west of the Peninsula de Azuero (Sectors 75–107). Two major habitat categories of importance to shorebirds and other coastal waterbirds (Butler et al. 1997) were chosen for the comparisons. The first involved sectors containing mangrove shorelines, whereas the second

consisted of sectors containing extensive mudflats in the intertidal zone.

## 7.4 Results

### 7.4.1 The influence of upwelling on major species groups

7.4.1.1 Mangroves and upwelling

For sectors containing mangroves, densities of all types of birds, including shorebirds, coastal seabirds, and wading birds, were significantly higher in areas affected by upwelling than in areas without upwelling (Table 7.1). Median densities were typically 40–50 times higher in mangrove sectors in upwelling areas than in mangrove sectors in non-upwelling areas (ranging up to 3650 times higher for small shorebirds), with mean densities some 10–45 times higher. In contrast, bird densities in non-mangrove habitats (all habitats other than those containing mangroves) were not significantly different between upwelling and non-upwelling areas: median densities were usually higher in the upwelling areas, but only by a factor of about 1–8 times (Table 7.1).

7.4.1.2 Mudflats and upwelling

For mudflat habitats, differences between upwelling and non-upwelling regions were less pronounced (Table 7.2). Median densities in mudflat habitats in upwelling areas were higher for all bird groups by a factor of some 3–14 times (up to 78 times for coastal seabirds), but results were generally either non-significant (Wilcoxon test, Rank ANOVA, and GT2 test) or only just of borderline significance ($0.1 > p > 0.05$, Median test). For non-mudflat habitats, differences between upwelling and non-upwelling habitats were not significant, except for coastal seabirds, where the Median test indicated that densities were higher in habitats in regions affected by upwelling.

### 7.4.2 Habitat associations for major species groups

7.4.2.1 Mangrove habitats

For sectors within upwelling regions, densities of most bird groups in mangrove habitats were significantly higher than in non-mangrove habitats (Table 7.3). Median densities ranged from a few tens of times (coastal seabirds, wading birds) to several hundred times (shorebirds) higher in mangrove habitats than in non-mangrove habitats, with mean densities a few times to a few tens of times higher (Table 7.3).

Differences in median and mean densities between mangrove and non-mangrove habitats in areas of no upwelling were much less pronounced and generally not significant (Table 7.3).

7.4.2.2 Mudflat habitats

Median densities of shorebirds and wading birds were generally significantly higher by a factor of some 35–150 times in sectors with mudflats than in sectors with no mudflats within areas of coastal upwelling. Coastal seabird densities did not appear to be affected by the presence of mudflats to the same degree as other bird groups, and differences between mudflat and non-mudflat areas within upwelling zones were not significant for this group (Table 7.4).

In areas with no coastal upwelling, although bird densities were usually somewhat higher in mudflat habitats than in non-mudflat habitats, differences were much less pronounced and not statistically significant (Table 7.4).

### 7.4.3 Upwelling and habitat associations for individual species/species groups

The same general patterns described above were noted for individual species within each of the major groups. Thus, many shorebird species (Tables 7.5 and 7.6) occurred in significantly higher densities in mangrove habitats in upwelling areas compared with non-upwelling areas, with differences being less apparent for non-mangrove habitats between upwelling and non-upwelling areas (Table 7.6a). The significantly higher densities of Black-bellied Plovers *Pluvialis squatarola* occurring in non-mangrove habitats in non-upwelling compared with upwelling areas appeared to be related to the regular occurrence of the species on coastal beaches in western Panama. For mudflat habitats, there were few differences between upwelling and non-upwelling areas for shorebirds (Table 7.6b). Again, Black-bellied Plovers occurred in significantly higher densities in non-mudflat habitats in the non-upwelling areas compared with upwelling areas, whereas dowitchers and Black-necked Stilts *Himantopus mexicanus* were found in significantly higher densities on non-mudflat habitats in the upwelling areas. Within upwelling areas, densities of all shorebirds were higher in mangrove than in non-mangrove habitats, many significantly so, and a similar pattern was found within the non-upwelling areas, although differences were less often significant (Table 7.6c). An exception was the Sanderling *Calidris alba*, which occurred in higher densities in the non-mangrove habitats in the non-upwelling regions, reflecting its occurrence on the beaches of western Panama. Generally similar results were found for the mudflat habitats (Table 7.6d).

For coastal seabirds (Tables 7.7 and 7.8), many species or species categories were found in significantly higher densities in mangrove habitats in upwelling compared with non-upwelling regions, and the same was found for cormorants and frigatebirds in non-mangrove habitats (Table 7.8a). Differences in densities in mudflat habitats between upwelling and non-upwelling areas were less consistent, although the strongly significant differences noted for cormorants and frigatebirds were again found between the upwelling and non-upwelling areas for both mudflat and non-mudflat categories (Table 7.8b). Within upwelling areas, gulls, terns, and pelicans occurred in higher densities in mangrove than in non-mangrove habitats (Table 7.8c), and cormorants occurred in higher densities on mudflat than on non-mudflat habitats (Table 7.8d). In non-upwelling areas, the only significant difference was for pelicans, which occurred in higher densities in non-mudflat habitats compared with mudflat habitats. These results all suggest that upwelling is particularly significant in affecting seabird distributions and that within the upwelling region, mangrove habitats are favoured by a number of species.

For wading birds (Tables 7.9 and 7.10), small egrets and Great Blue Herons *Ardea herodias* were found in higher densities in mangroves in upwelling areas compared with non-upwelling areas (Table 7.10a), although few other differences were noted between upwelling and non-upwelling regions for non-mangrove, mudflat, or non-mudflat categories (Table 7.10a,b). Within upwelling

zones, small egrets, Great Blue Herons, and Great Egrets *Ardea alba* all occurred in significantly higher densities in mangrove habitats compared with non-mangrove habitats, and small egrets occurred in significantly higher densities in mudflat habitats compared with non-mudflat habitats; in the non-upwelling regions, only White Ibises *Eudocimus albus* and Little Blue Herons *Egretta caerulea* were found in significantly higher densities in mudflat habitats compared with non-mudflat habitats, no significant differences being noted for densities in mangrove compared with non-mangrove areas (Table 7.10c,d).

## 7.5 Discussion

For all the major coastal bird groups, distribution was influenced both by the presence or absence of upwelling and by preferences for particular habitats. Most groups occurred in higher densities in mangrove or in mudflat habitats in areas of upwelling compared with areas of non-upwelling, and many were found in higher densities in mangrove compared with non-mangrove habitats (or mudflat habitats vs. non-mudflat habitats) within areas of upwelling. Coastal seabirds were less influenced than shorebirds or wading birds by the type of coastal habitat present, although they responded strongly to the presence of upwelling. For seabirds feeding on fish or other organisms in marine waters either near the coast or offshore, this would appear logical, as the birds would be influenced more directly by the abundance of food in the waters themselves rather than by the abundance of food in coastal habitats. For shorebirds and wading birds that feed directly within habitats occurring on the shoreline itself, the type of habitat and substrate available as well as the amount and type of food occurring in such habitats will be important factors influencing distribution. Mangroves form a highly productive ecosystem that supports a diverse community of invertebrates and fish, which provide the food resources used by shorebirds, coastal seabirds, and wading birds (Cawkwell 1964; Odum and Heald 1972; Snedaker and Brown 1982; Simberloff 1983). Productivity within the mangrove ecosystem is likely to be enhanced where the availability of nutrients is increased as a result of upwelling. Moreover, many species roost in mangroves, including the Willet *Catoptrophorus semipalmatus*, Whimbrel *Numenius phaeopus*, Brown Pelican *Pelecanus occidentalis*, Magnificent Frigatebird *Fregata magnificens*, Snowy Egret *Egretta thula*, Great Egret, Great Blue Heron, Little Blue Heron, Yellow-crowned Night-Heron *Nycticorax violaceus*, and Black-crowned Night-Heron *N. nycticorax*.

In the present analysis, statistically significant habitat preferences were clearly evident for many types of birds within upwelling areas based on two major habitat types — namely, mangrove (vs. non-mangrove) and mudflat (vs. non-mudflat). In non-upwelling areas, densities were also usually higher in mangrove or mudflat categories (compared with non-mangrove and non-mudflat, respectively), although differences were not as great and usually not statistically significant. The highest densities of birds generally occurred in sectors containing both mudflats and mangroves. Six of the seven habitat sectors containing the mudflat/mangrove combination were located in the Golfo de Panama, five being in the northern gulf east of Panama City, with another sector in Bahia de Parita near Chitre. These areas all contained well-developed, extensive mudflats and are influenced by oceanic upwelling (D'Croz et al. 1991), which would likely increase the productivity of potential food items. The other mangrove/mudflat sector was located in an inlet off the Golfo de Chiriqui (near Punta Entrada) in western Panama, where oceanic upwelling is considerably less, and bird densities in this sector were by far the lowest for this habitat combination. Using data from all survey sectors in Panama, Butler et al. (1997) showed that highest bird densities occurred in mudflat/mangrove habitats, with progressively lower densities on mudflat/non-mangrove, non-mudflat/mangrove, and "other" habitats. Differences between the most and least heavily used habitats were generally statistically significant, with less clear-cut differences between intermediate combinations.

Not all sectors that contain mudflats also contain mangroves. Sectors with mudflats backed by stands of tropical forest leading back from the shore were found mostly in the more sheltered parts of the eastern Golfo de Panama, as well as in sheltered inlets around the Peninsula de Azuero. It is possible that they are less influenced by oceanic upwelling and are somewhat less productive than the more open mudflats in the northern part of the Golfo de Panama. Non-mudflat sectors consisted mostly of sandy shores or flats backed by mangroves; these types of habitats were found in the western Golfo de Panama and in inlets and along shores in the western part of the country. Such areas contained substrates less likely to contain food resources used by birds such as shorebirds and were often in areas where biological productivity was lower. "Other" types of habitats consisted of a variety of sandy, rocky, or steep mountainous shorelines along the Pacific coast, most providing little suitable habitat for shorebirds or other coastal waterbirds.

Shorebird surveys on South American wintering grounds also pointed to the importance of coastlines with combinations of mudflat and mangrove habitats (Morrison and Ross 1989). Especially large numbers of shorebirds were found along the north coast of the continent in Suriname and French Guiana, where sediments discharged from the Amazon River are deposited to form huge mudflats, often backed by mangroves. Extensive intertidal areas with a variety of substrate types are found in the drowned river valleys along the coastline of north-central Brasil east of the mouth of the Amazon River, and these areas contain some of the most impressive stands of mangroves in South America. Highly significant numbers and a wide diversity of shorebird species winter in the area.

As the data from Panama indicate, however, the presence of mudflats and mangroves alone is not necessarily enough to produce conditions that will support large numbers of shorebirds. Morrison and Ross (1989) noted a number of areas on the tropical coastlines of northeastern Brasil, as well as on the northern sections of the Pacific coastline of South America, where mudflat/mangrove systems occurred with only low concentrations of shorebirds. It is possible that such areas may not contain food of the right type or size for all groups of birds, and many such areas appear to occur where enhanced input of nutrients, as would result from upwelling, does not occur.

It would thus appear that habitats used heavily by shorebirds and other waterbirds occur where a combination of geomorphological and oceanographic conditions lead to the formation of highly productive, broad mudflats backed by mangroves. Mudflat/mangrove systems are of major im-

portance to shorebirds wintering in tropical areas of east Asia and Australasia (Parish et al. 1987). Areas of particularly high shorebird densities in Africa have also been associated with the highly productive coastlines associated with nutrient-rich sediments produced by coastal upwelling (Tye 1987). The conservational implications of these findings are important, as they suggest that habitats used by significant numbers of birds are able to form only at certain geographical locations. Displacement of large concentrations of birds to superficially similar habitats elsewhere would not necessarily occur or would occur only to a limited extent, as conditions are unlikely to be such that alternative areas would be able to support similar numbers of birds.

Our analysis that large numbers of coastal birds in Panama are associated with shorelines near oceanic upwelling suggests that these populations might respond negatively to reduced upwelling during strong El Niño – Southern Oscillation (ENSO) events in Panama. Smith (1990) showed that seabirds suffered high mortality during El Niño events in Bahia de Panama, but the impact on survival and distribution of other coastal birds in Panama is unknown. Population densities of Nearctic shorebirds that winter in the tropical Pacific might be strongly linked to ecosystem processes derived from oceanic upwelling and ultimately to the frequency and strength of ENSO events.

## 7.6 Literature cited


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**Table 7.1**
Comparison of median (and mean ± SD) bird densities in areas of oceanic upwelling and non-upwelling for mangrove and non-mangrove habitats on the Pacific coast of Panama during surveys in January 1993

| | | | | | Habitats containing mangroves | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Upwelling (n = 18) | | Non-upwelling (n = 12) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | ** | ** | ** | * | 73.03 | 633.08 ± 1305.95 | 0.02 | 10.00 ± 28.60 |
| Medium-sized shorebirds | ** | ** | ** | * | 7.25 | 34.81 ± 65.34 | 0.14 | 2.80 ± 5.48 |
| Large shorebirds | * | (ns) | * | * | 5.80 | 10.30 ± 11.30 | 1.02 | 1.69 ± 2.54 |
| **Total shorebirds** | ** | ** | ** | * | 121.67 | 678.20 ± 1319.81 | 2.20 | 14.49 ± 33.85 |
| **Coastal seabirds** | *** | *** | *** | * | 32.78 | 57.96 ± 66.63 | 0.69 | 3.11 ± 5.85 |
| **Wading birds** | ** | (ns) | ** | * | 1.67 | 1.71 ± 1.26 | 0.08 | 0.17 ± 0.23 |
| **Birds of prey** | * | * | * | * | 0.02 | 0.35 ± 0.50 | 0 | 0.002 ± 0.005 |
| **Total birds** | ** | ** | *** | * | 211.52 | 738.23 ± 1310.73 | 4.66 | 17.76 ± 36.60 |

| | | | | | Habitats NOT containing mangroves | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Upwelling (n = 24) | | Non-upwelling (n = 19) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | ns | ns | ns | ns | 0.37 | 26.76 ± 65.92 | 0.06 | 2.66 ± 3.98 |
| Medium-sized shorebirds | ns | ns | ns | ns | 0.02 | 2.99 ± 7.55 | 0.07 | 0.86 ± 2.68 |
| Large shorebirds | ns | ns | ns | ns | 0.04 | 2.51 ± 7.80 | 0.04 | 0.94 ± 2.87 |
| **Total shorebirds** | ns | ns | ns | ns | 1.97 | 32.26 ± 70.80 | 0.25 | 4.46 ± 7.68 |
| **Coastal seabirds** | ns | ns | ns | ns | 1.99 | 5.48 ± 7.25 | 1.03 | 5.74 ± 9.83 |
| **Wading birds** | ns | ns | ns | ns | 0.04 | 1.60 ± 3.19 | 0.11 | 0.33 ± 0.62 |
| **Birds of prey** | ns | ns | ns | ns | 0.02 | 0.08 ± 0.13 | 0 | 0.05 ± 0.10 |
| **Total birds** | ns | ns | ns | ns | 4.86 | 39.52 ± 79.10 | 3.32 | 10.58 ± 12.86 |

Statistical tests: Wilcoxon and Median tests compare median values in each group. Rank ANOVA indicates difference in groups based on ANOVA of rank values, and GT2 indicates comparison of means using Studentized Maximum Modulus test. Significance levels: ns = not significant, (ns) = $0.1 > p > 0.05$, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. Median = 0 indicates birds were seen on less than half of the survey sectors.

**Table 7.2**
Comparison of median (and mean ± SD) bird densities in areas of oceanic upwelling and non-upwelling for mudflat and non-mudflat habitats on the Pacific coast of Panama during surveys in January 1993

| | | | | | Habitats containing mudflats | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Upwelling (n = 10) | | Non-upwelling (n = 3) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | ns | (ns) | ns | ns | 73.03 | 519.10 ± 1177.07 | 5.00 | 3.72 ± 3.21 |
| Medium-sized shorebirds | ns | ns | ns | ns | 6.09 | 28.17 ± 59.32 | 0.16 | 3.98 ± 6.75 |
| Large shorebirds | ns | ns | ns | ns | 5.80 | 10.88 ± 12.51 | 2.03 | 4.88 ± 6.75 |
| **Total shorebirds** | ns | (ns) | ns | ns | 112.45 | 558.15 ± 1191.99 | 7.20 | 12.58 ± 15.88 |
| **Coastal seabirds** | (ns) | (ns) | (ns) | ns | 16.37 | 17.57 ± 16.06 | 0.21 | 0.90 ± 1.32 |
| **Wading birds** | ns | (ns) | ns | ns | 1.73 | 2.34 ± 2.65 | 0.19 | 0.20 ± 0.06 |
| **Birds of prey** | ns | (ns) | (ns) | ns | 0.04 | 0.20 ± 0.33 | 0 | 0 |
| **Total birds** | ns | (ns) | ns | ns | 134.12 | 578.26 ± 1202.98 | 9.89 | 13.68 ± 15.58 |

| | | | | | Habitats NOT containing mudflats | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Upwelling (n = 12) | | Non-upwelling (n = 28) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | ns | ns | ns | ns | 0.62 | 20.70 ± 61.95 | 0.04 | 5.69 ± 18.90 |
| Medium-sized shorebirds | ns | ns | ns | ns | 0.04 | 3.22 ± 8.09 | 0.06 | 1.36 ± 3.74 |
| Large shorebirds | ns | ns | ns | ns | 0.04 | 0.73 ± 1.42 | 0.07 | 0.84 ± 1.81 |
| **Total shorebirds** | ns | ns | ns | ns | 3.19 | 24.64 ± 62.12 | 1.01 | 7.89 ± 22.64 |
| **Coastal seabirds** | ns | * | ns | ns | 3.00 | 30.40 ± 62.21 | 1.02 | 5.13 ± 8.85 |
| **Wading birds** | ns | ns | ns | ns | 0.04 | 1.06 ± 2.54 | 0.09 | 0.28 ± 0.53 |
| **Birds of prey** | ns | ns | ns | ns | 0 | 0.17 ± 0.36 | 0 | 0.03 ± 0.09 |
| **Total birds** | ns | ns | ns | ns | 8.14 | 56.38 ± 86.67 | 3.42 | 13.33 ± 25.54 |

Statistical tests: Wilcoxon and Median tests compare median values in each group. Rank ANOVA indicates difference in groups based on ANOVA of rank values, and GT2 indicates comparison of means using Studentized Maximum Modulus test. Significance levels: ns = not significant, (ns) = $0.1 > p > 0.05$, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. Median = 0 indicates birds were seen on less than half of the survey sectors.

**Table 7.3**
Comparison of median (and mean ± SD) bird densities in habitats with and without mangroves in areas with oceanic upwelling and with no oceanic upwelling on the Pacific coast of Panama during surveys in January 1993

| | | | | | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Habitats with mangroves (n = 8) | | Habitats without mangroves (n = 14) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | * | (ns) | ** | * | 73.03 | 633.08 ± 1305.95 | 0.37 | 26.76 ± 65.92 |
| Medium-sized shorebirds | ** | ** | ** | * | 7.25 | 34.81 ± 65.34 | 0.02 | 2.99 ± 7.55 |
| Large shorebirds | ** | *** | *** | * | 5.80 | 10.30 ± 11.30 | 0.04 | 2.51 ± 7.80 |
| **Total shorebirds** | ** | ** | ** | * | 121.67 | 678.20 ± 1319.81 | 1.97 | 32.26 ± 70.80 |
| **Coastal seabirds** | ** | ** | ** | * | 32.78 | 57.96 ± 66.63 | 1.99 | 5.48 ± 7.25 |
| **Wading birds** | ns | (ns) | (ns) | ns | 1.67 | 1.71 ± 1.26 | 0.04 | 1.60 ± 3.19 |
| **Birds of prey** | ns | ns | ns | ns | 0.02 | 0.35 ± 0.50 | 0.02 | 0.08 ± 0.13 |
| **Total birds** | ** | *** | ** | * | 211.52 | 738.23 ± 1310.73 | 4.86 | 39.52 ± 79.10 |

| | | | | | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Habitats with mangrove (n = 12) | | Habitats without mangroves (n = 19) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | ns | ns | ns | ns | 0.02 | 10.00 ± 28.60 | 0.06 | 2.66 ± 3.98 |
| Medium-sized shorebirds | ns | ns | ns | ns | 0.14 | 2.80 ± 5.48 | 0.07 | 0.86 ± 2.68 |
| Large shorebirds | * | ns | * | * | 1.02 | 1.69 ± 2.54 | 0.04 | 0.94 ± 2.87 |
| **Total shorebirds** | ns | ns | ns | ns | 2.20 | 14.49 ± 33.85 | 0.25 | 4.46 ± 7.68 |
| **Coastal seabirds** | ns | ns | ns | ns | 0.69 | 3.11 ± 5.85 | 1.03 | 5.74 ± 9.83 |
| **Wading birds** | ns | ns | ns | ns | 0.08 | 0.17 ± 0.23 | 0.11 | 0.33 ± 0.62 |
| **Birds of prey** | (ns) | (ns) | (ns) | ns | 0 | 0.002 ± 0.005 | 0 | 0.05 ± 0.10 |
| **Total birds** | ns | ns | ns | ns | 4.66 | 17.76 ± 36.60 | 3.32 | 10.58 ± 12.86 |

Statistical tests: Wilcoxon and Median tests compare median values in each group. Rank ANOVA indicates difference in groups based on ANOVA of rank values, and GT2 indicates comparison of means using Studentized Maximum Modulus test. Significance levels: ns = not significant, (ns) = $0.1 > p > 0.05$, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. Median = 0 indicates birds were seen on less than half of the survey sectors.

**Table 7.4**
Comparison of median (and mean ± SD) bird densities in habitats with and without mudflats in areas with oceanic upwelling and with no oceanic upwelling on the Pacific coast of Panama during surveys in January 1993

| | | | | | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Habitats with mudflats (n = 10) | | Habitats without mudflats (n = 12) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | ns | (ns) | ns | ns | 73.03 | 519.10 ± 1177.07 | 0.62 | 20.70 ± 61.95 |
| Medium-sized shorebirds | * | * | * | * | 6.09 | 28.17 ± 59.32 | 0.04 | 3.22 ± 8.09 |
| Large shorebirds | ** | * | ** | * | 5.80 | 10.88 ± 12.51 | 0.04 | 0.73 ± 1.42 |
| **Total shorebirds** | (ns) | (ns) | (ns) | ns | 112.45 | 558.15 ± 1191.99 | 3.19 | 24.64 ± 62.12 |
| **Coastal seabirds** | ns | ns | ns | ns | 16.37 | 17.57 ± 16.06 | 3.00 | 30.40 ± 62.21 |
| **Wading birds** | (ns) | * | * | * | 1.73 | 2.34 ± 2.65 | 0.04 | 1.06 ± 2.54 |
| **Birds of prey** | ns | ns | ns | ns | 0.04 | 0.20 ± 0.33 | 0 | 0.17 ± 0.36 |
| **Total birds** | (ns) | ns | ns | ns | 134.12 | 578.26 ± 1202.98 | 8.14 | 56.38 ± 86.67 |

| | | | | | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Habitats with mudflats (n = 3) | | Habitats without mudflats (n = 28) | |
| | Wilcoxon | Median | Rank ANOVA | GT2 | Median | Mean ± SD | Median | Mean ± SD |
| Small shorebirds | ns | (ns) | ns | ns | 5.00 | 3.72 ± 3.21 | 0.04 | 5.69 ± 18.90 |
| Medium-sized shorebirds | ns | ns | ns | ns | 0.16 | 3.98 ± 6.75 | 0.06 | 1.36 ± 3.74 |
| Large shorebirds | ns | ns | ns | ns | 2.03 | 4.88 ± 6.75 | 0.07 | 0.84 ± 1.81 |
| **Total shorebirds** | ns | ns | ns | ns | 7.20 | 12.58 ± 15.88 | 1.01 | 7.89 ± 22.64 |
| **Coastal seabirds** | ns | ns | ns | ns | 0.21 | 0.90 ± 1.32 | 1.02 | 5.13 ± 8.85 |
| **Wading birds** | ns | (ns) | ns | ns | 0.19 | 0.20 ± 0.06 | 0.09 | 0.28 ± 0.53 |
| **Birds of prey** | ns | ns | ns | ns | 0 | 0 | 0 | 0.03 ± 0.09 |
| **Total birds** | ns | ns | ns | ns | 9.89 | 13.68 ± 15.58 | 3.42 | 13.33 ± 25.54 |

Statistical tests: Wilcoxon and Median tests compare median values in each group. Rank ANOVA indicates difference in groups based on ANOVA of rank values, and GT2 indicates comparison of means using Studentized Maximum Modulus test. Significance levels: ns = not significant, (ns) = $0.1 > p > 0.05$, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. Median = 0 indicates birds were seen on less than half of the survey sectors.

**Table 7.5**
Median (and mean ± SD) shorebird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

| | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|
| | Mangrove (n = 8) | | Non-mangrove (n = 14) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Sanderling | 0 | 0.64 ± 1.45 | 0 | 0.19 ± 0.41 |
| Spotted Sandpiper | 0 | 0.01 ± 0.03 | 0 | 0.004 ± 0.013 |
| Small shorebirds | 73.03 | 633.09 ± 1305.95 | 0.37 | 26.76 ± 65.92 |
| Black-bellied Plover | 0.08 | 0.62 ± 1.20 | 0 | 0.003 ± 0.011 |
| Ruddy Turnstone | 0 | 0.13 ± 0.24 | 0 | 0.01 ± 0.05 |
| Dowitchers | 0 | 8.52 ± 19.14 | 0 | 2.19 ± 7.58 |
| Medium-sized shorebirds | 7.26 | 34.81 ± 65.34 | 0.02 | 2.99 ± 7.55 |
| Whimbrel | 1.97 | 2.48 ± 2.72 | 0 | 0.39 ± 1.33 |
| Willet | 3.33 | 7.28 ± 9.45 | 0.02 | 2.11 ± 6.49 |
| Oystercatcher | 0.26 | 0.41 ± 0.47 | 0 | 0.003 ± 0.011 |
| Black-necked Stilt | 0 | 0.28 ± 0.75 | 0 | 0.01 ± 0.04 |
| Large shorebirds | 5.80 | 10.30 ± 11.30 | 0.04 | 2.51 ± 7.80 |

| | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|
| | Mangrove (n = 12) | | Non-mangrove (n = 19) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Sanderling | 0 | 0.002 ± 0.006 | 0 | 1.03 ± 2.33 |
| Spotted Sandpiper | 0 | 0.06 ± 0.13 | 0 | 0.06 ± 0.15 |
| Small shorebirds | 0.02 | 10.00 ± 28.60 | 0.06 | 2.66 ± 3.98 |
| Black-bellied Plover | 0 | 0.16 ± 0.39 | 0 | 0.12 ± 0.31 |
| Ruddy Turnstone | 0 | 0.48 ± 1.24 | 0 | 0.08 ± 0.28 |
| Dowitchers | 0 | 0 | 0 | 0.51 ± 2.21 |
| Medium-sized shorebirds | 0.14 | 2.80 ± 5.48 | 0.07 | 0.86 ± 2.68 |
| Whimbrel | 0.27 | 0.63 ± 0.85 | 0.03 | 0.45 ± 1.33 |
| Willet | 0.40 | 1.03 ± 2.80 | 0 | 0.45 ± 1.55 |
| Oystercatcher | 0 | 0.03 ± 0.011 | 0 | 0.04 ± 0.12 |
| Black-necked Stilt | 0 | 0 | 0 | 0 |
| Large shorebirds | 1.02 | 1.69 ± 2.54 | 0.04 | 0.94 ± 2.87 |

| | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|
| | Mudflat (n = 10) | | Non-mudflat (n = 12) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Sanderling | 0 | 0.41 ± 1.30 | 0.02 | 0.30 ± 0.48 |
| Spotted Sandpiper | 0 | 0.01 ± 0.03 | 0 | 0.004 ± 0.014 |
| Small shorebirds | 73.03 | 519.10 ± 1177.07 | 0.62 | 20.70 ± 61.95 |
| Black-bellied Plover | 0.02 | 0.50 ± 1.09 | 0 | 0 |
| Ruddy Turnstone | 0 | 0.12 ± 0.21 | 0 | 0 |
| Dowitchers | 0 | 6.65 ± 17.30 | 0 | 2.70 ± 8.19 |
| Medium-sized shorebirds | 6.10 | 28.17 ± 59.32 | 0.04 | 3.22 ± 8.09 |
| Whimbrel | 1.97 | 2.37 ± 2.75 | 0 | 0.14 ± 0.39 |
| Willet | 3.33 | 8.16 ± 10.38 | 0.02 | 0.50 ± 1.30 |
| Oystercatcher | 0 | 0.27 ± 0.46 | 0 | 0.05 ± 0.15 |
| Black-necked Stilt | 0 | 0.01 ± 0.03 | 0 | 0.19 ± 0.62 |
| Large shorebirds | 5.80 | 10.88 ± 12.51 | 0.04 | 0.73 ± 1.42 |

*Continued*

**Table 7.5** *(cont'd)*
Median (and mean ± SD) shorebird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

| | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|
| | Mudflat (n = 3) | | Non-mudflat (n = 28) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Sanderling | 0 | 1.56 ± 2.70 | 0 | 0.54 ± 1.81 |
| Spotted Sandpiper | 0.06 | 0.04 ± 0.03 | 0 | 0.06 ± 0.15 |
| Small shorebirds | 5 | 3.72 ± 3.21 | 0.05 | 5.69 ± 18.90 |
| Black-bellied Plover | 0.03 | 0.06 ± 0.08 | 0 | 0.14 ± 0.35 |
| Ruddy Turnstone | 0 | 0 | 0 | 0.26 ± 0.84 |
| Dowitchers | 0 | 3.21 ± 5.57 | 0 | 0 |
| Medium-sized shorebirds | 0.16 | 3.98 ± 6.75 | 0.06 | 1.36 ± 3.74 |
| Whimbrel | 1.21 | 2.33 ± 3.02 | 0.06 | 0.32 ± 0.63 |
| Willet | 0.82 | 2.53 ± 3.70 | 0.04 | 0.47 ± 1.26 |
| Oystercatcher | 0 | 0.02 ± 0.03 | 0 | 0.04 ± 0.12 |
| Black-necked Stilt | 0 | 0 | 0 | 0 |
| Large shorebirds | 2.03 | 4.88 ± 6.75 | 0.07 | 0.84 ± 1.81 |

**Table 7.6**
Comparison of shorebird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

(a) Effects of upwelling on shorebird densities in mangrove/non-mangrove habitats

| | Mangrove habitats Upwelling (n = 8) vs. Non-upwelling (n = 12) | | | | | Non-mangrove habitats Upwelling (n = 14) vs. Non-upwelling (n = 19) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 |
| Sanderling | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Spotted Sandpiper | n | ns | ns | ns | ns | n | * | (ns) | * | * |
| Small shorebirds | y | ** | ** | ** | * | y | ns | ns | ns | ns |
| Black-bellied Plover | y | ns | ns | ns | ns | n | * | * | * | * |
| Ruddy Turnstone | n | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Dowitchers | y | * | * | * | * | y | ns | ns | ns | ns |
| Medium-sized shorebirds | y | ** | ** | ** | * | y | ns | ns | ns | ns |
| Whimbrel | y | (ns) | (ns) | (ns) | ns | n | ns | ns | ns | ns |
| Willet | y | (ns) | (ns) | ns | ns | y | ns | ns | ns | ns |
| Oystercatcher | y | (ns) | ns | (ns) | ns | n | ns | ns | ns | ns |
| Black-necked Stilt | y | * | * | * | * | y | ns | ns | ns | ns |
| Large shorebirds | y | * | (ns) | * | * | y | ns | ns | ns | ns |

(b) Effects of upwelling on shorebird densities in mudflat/non-mudflat habitats

| | Mudflat habitats Upwelling (n = 10) vs. Non-upwelling (n = 3) | | | | | Non-mudflat habitats Upwelling (n = 12) vs. Non-upwelling (n = 28) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 |
| Sanderling | n | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Spotted Sandpiper | n | ns | * | (ns) | ns | n | ns | ns | (ns) | ns |
| Small shorebirds | y | ns | (ns) | ns | ns | y | ns | ns | ns | ns |
| Black-bellied Plover | y | ns | ns | ns | ns | n | * | * | * | * |
| Ruddy Turnstone | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Dowitchers | y | ns | ns | ns | ns | y | * | * | * | * |
| Medium-sized shorebirds | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Whimbrel | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Willet | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Oystercatcher | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Black-necked Stilt | y | ns | ns | ns | ns | y | * | * | * | * |
| Large shorebirds | y | ns | ns | ns | ns | n | ns | ns | ns | ns |

(c) Habitat (mangrove/non-mangrove) associations of shorebirds within upwelling/non-upwelling zones

| | Areas with UPWELLING Mangrove (n = 8) vs. Non-mangrove (n = 14) | | | | | Areas with NO UPWELLING Mangrove (n = 12) vs. Non-mangrove (n = 19) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mangrove > Non-mangrove | Wilcoxon | Median | Rank ANOVA | GT2 | Mangrove > Non-mangrove | Wilcoxon | Median | Rank ANOVA | GT2 |
| Sanderling | y | ns | ns | ns | ns | n | * | * | * | * |
| Spotted Sandpiper | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Small shorebirds | y | * | (ns) | ** | * | y | ns | ns | ns | ns |
| Black-bellied Plover | y | * | * | ** | * | y | ns | ns | ns | ns |
| Ruddy Turnstone | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Dowitchers | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Medium-sized shorebirds | y | ** | *** | ** | * | y | ns | ns | ns | ns |
| Whimbrel | y | ** | ** | *** | * | y | ns | ns | (ns) | ns |
| Willet | y | * | ** | ** | * | y | * | ns | * | * |
| Oystercatcher | y | * | * | * | * | n | ns | ns | ns | ns |
| Black-necked Stilt | y | ns | (ns) | (ns) | ns | – | – | – | – | * |
| Large shorebirds | y | ** | *** | * | * | y | * | * | * | * |

*Continued*

**Table 7.6** *(cont'd)*
Comparison of shorebird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

(d) Habitat (mudflat/non-mudflat) associations of shorebirds within upwelling/non-upwelling zones

| | Areas with UPWELLING Mudflat (n = 10) vs. Non-mudflat (n = 12) | | | | | Areas with NO UPWELLING Mudflat (n = 3) vs. Non-mudflat (n = 28) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mudflat > Non-mudflat | Wilcoxon | Median | Rank ANOVA | GT2 | Mudflat > Non-mudflat | Wilcoxon | Median | Rank ANOVA | GT2 |
| Sanderling | y | ns | * | (ns) | ns | y | ns | ns | ns | ns |
| Spotted Sandpiper | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Small shorebirds | y | ns | (ns) | ns | ns | n | ns | (ns) | ns | ns |
| Black-bellied Plover | y | ** | ** | ** | * | n | ns | ns | ns | ns |
| Ruddy Turnstone | y | (ns) | * | * | * | n | ns | ns | ns | ns |
| Dowitchers | y | ns | ns | ns | ns | y | ** | ** | ** | * |
| Medium-sized shorebirds | y | * | * | * | * | y | ns | ns | ns | ns |
| Whimbrel | y | * | (ns) | * | * | y | ns | ns | (ns) | ns |
| Willet | y | * | (ns) | * | * | y | ns | ns | ns | ns |
| Oystercatcher | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Black-necked Stilt | n | ns | ns | ns | ns | – | – | – | – | (ns) |
| Large shorebirds | y | ** | * | ** | * | y | ns | ns | ns | ns |

Statistical tests: Wilcoxon and Median tests compare median values in each group. Rank ANOVA indicates difference in groups based on ANOVA of rank values, and GT2 indicates comparison of means using Studentized Maximum Modulus test (SAS Institute, Inc. 1988). Significance levels: ns = not significant, (ns) = $0.1 > p > 0.05$, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. For numerical values of densities, refer to Table 7.5. "y" (yes) and "n" (no) indicate whether median value (or mean if median is zero) of category 1 > category 2 as shown. Dashes indicate that sample sizes were too small for meaningful analysis.

**Table 7.7**
Median (and mean ± SD) coastal seabird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

| | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|
| | Mangrove (n = 8) | | Non-mangrove (n = 14) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Gulls | 8.43 | 30.42 ± 53.98 | 0.60 | 3.50 ± 6.38 |
| Terns | 3.38 | 20.59 ± 33.72 | 0.80 | 0.51 ± 0.85 |
| Large terns | 0 | 0.005 ± 0.015 | 0 | 0.02 ± 0.04 |
| Brown Pelican | 2.05 | 4.40 ± 5.00 | 0.01 | 1.10 ± 2.09 |
| Neotropic Cormorant | 0.13 | 1.59 ± 2.43 | 0.02 | 0.22 ± 0.32 |
| Magnificent Frigatebird | 0.38 | 0.96 ± 1.77 | 0.08 | 0.15 ± 0.19 |
| Brown Booby | 0 | 0 | 0 | 0 |
| Red-billed Tropicbird | 0 | 0 | 0 | 0 |

| | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|
| | Mangrove (n = 12) | | Non-mangrove (n = 19) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Gulls | 0.01 | 1.49 ± 4.36 | 0 | 1.33 ± 2.24 |
| Terns | 0.14 | 1.24 ± 2.84 | 0 | 2.80 ± 7.40 |
| Large terns | 0 | 0 | 0 | 0.002 ± 0.008 |
| Brown Pelican | 0.07 | 0.33 ± 1.47 | 0.42 | 1.58 ± 3.04 |
| Neotropic Cormorant | 0 | 0 | 0 | 0 |
| Magnificent Frigatebird | 0.03 | 0.05 ± 0.07 | 0 | 0.03 ± 0.06 |
| Brown Booby | 0 | 0 | 0 | 0 |
| Red-billed Tropicbird | 0 | 0 | 0 | 0 |

| | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|
| | Mudflat (n = 10) | | Non-mudflat (n = 12) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Gulls | 5.75 | 9.36 ± 10.04 | 1.84 | 16.56 ± 46.14 |
| Terns | 0.83 | 3.53 ± 7.59 | 0.14 | 11.38 ± 28.87 |
| Large terns | 0 | 0.004 ± 0.013 | 0 | 0.02 ± 0.05 |
| Brown Pelican | 0.53 | 2.47 ± 4.25 | 0.41 | 2.15 ± 3.37 |
| Neotropic Cormorant | 0.56 | 1.45 ± 2.15 | 0 | 0.10 ± 0.23 |
| Magnificent Frigatebird | 0.23 | 0.75 ± 1.61 | 0.09 | 0.18 ± 0.21 |
| Brown Booby | 0 | 0 | 0 | 0 |
| Red-billed Tropicbird | 0 | 0 | 0 | 0 |

| | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|
| | Mudflat (n = 3) | | Non-mudflat (n = 28) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Gulls | 0 | 0.59 ± 1.02 | 0.01 | 1.48 ± 3.31 |
| Terns | 0.21 | 0.29 ± 0.34 | 0.02 | 2.40 ± 6.32 |
| Large terns | 0 | 0 | 0 | 0.001 ± 0.007 |
| Brown Pelican | 0 | 0.02 ± 0.04 | 0.32 | 1.21 ± 2.56 |
| Neotropic Cormorant | 0 | 0 | 0 | 0 |
| Magnificent Frigatebird | 0 | 0 | 0 | 0.04 ± 0.07 |
| Brown Booby | 0 | 0 | 0 | 0 |
| Red-billed Tropicbird | 0 | 0 | 0 | 0 |

**Table 7.8**
Comparison of coastal seabird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

(a) Effects of upwelling on coastal seabird densities in mangrove/non-mangrove habitats

| | Mangrove habitats Upwelling (n = 8) vs. Non-upwelling (n = 12) | | | | | Non-mangrove habitats Upwelling (n = 14) vs. Non-upwelling (n = 19) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 |
| Gulls | y | *** | *** | *** | * | y | ns | ns | ns | ns |
| Terns | y | * | (ns) | * | * | n | ns | ns | ns | ns |
| Large terns | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Brown Pelican | y | * | (ns) | * | * | n | ns | ns | ns | ns |
| Neotropic Cormorant | y | *** | *** | * | * | y | *** | *** | *** | * |
| Magnificent Frigatebird | y | * | (ns) | * | * | y | ** | ** | ** | * |
| Brown Booby | – | – | – | – | – | – | – | – | – | – |
| Red-tailed Tropicbird | – | – | – | – | – | – | – | – | – | – |

(b) Effects of upwelling on coastal seabird densities in mudflat/non-mudflat habitats

| | Mudflat habitats Upwelling (n = 10) vs. Non-upwelling (n = 3) | | | | | Non-mudflat habitats Upwelling (n = 12) vs. Non-upwelling (n = 28) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 |
| Gulls | y | ns | (ns) | (ns) | ns | y | (ns) | ns | (ns) | ns |
| Terns | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Large terns | y | ns | ns | ns | ns | y | * | * | * | * |
| Brown Pelican | y | ns | (ns) | (ns) | ns | y | ns | ns | ns | ns |
| Neotropic Cormorant | y | * | (ns) | ** | * | y | *** | *** | *** | * |
| Magnificent Frigatebird | y | * | (ns) | * | * | y | ** | ** | ** | * |
| Brown Booby | – | – | – | – | – | – | – | – | – | – |
| Red-tailed Tropicbird | – | – | – | – | – | – | – | – | – | – |

(c) Habitat (mangrove/non-mangrove) associations of coastal seabirds within upwelling/non-upwelling zones

| | Areas with UPWELLING Mangrove (n = 8) vs. Non-mangrove (n = 14) | | | | | Areas with NO UPWELLING Mangrove (n = 12) vs. Non-mangrove (n = 19) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mangrove > Non-mangrove | Wilcoxon | Median | Rank ANOVA | GT2 | Mangrove > Non-mangrove | Wilcoxon | Median | Rank ANOVA | GT2 |
| Gulls | y | ** | ** | ** | * | y | ns | ns | ns | ns |
| Terns | y | ** | (ns) | ** | * | n | ns | ns | ns | ns |
| Large terns | n | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Brown Pelican | y | * | (ns) | * | * | n | ns | ns | ns | ns |
| Neotropic Cormorant | y | ns | ns | (ns) | ns | – | – | – | – | – |
| Magnificent Frigatebird | y | (ns) | (ns) | ns | ns | y | ns | (ns) | ns | ns |
| Brown Booby | – | – | – | – | – | – | – | – | – | – |
| Red-tailed Tropicbird | – | – | – | – | – | – | – | – | – | – |

(d) Habitat (mudflat/non-mudflat) associations of coastal seabirds within upwelling/non-upwelling zones

| | Areas with UPWELLING Mudflat (n = 10) vs. Non-mudflat (n = 12) | | | | | Areas with NO UPWELLING Mudflat (n = 3) vs. Non-mudflat (n = 28) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mudflat > Non-mudflat | Wilcoxon | Median | Rank ANOVA | GT2 | Mudflat > Non-mudflat | Wilcoxon | Median | Rank ANOVA | GT2 |
| Gulls | n | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Terns | n | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Large terns | n | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Brown Pelican | y | ns | ns | ns | ns | n | * | (ns) | * | * |
| Neotropic Cormorant | y | * | (ns) | ** | * | – | – | – | – | – |
| Magnificent Frigatebird | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Brown Booby | – | – | – | – | – | – | – | – | – | – |
| Red-tailed Tropicbird | – | – | – | – | – | – | – | – | – | – |

Statistical tests: Wilcoxon and Median tests compare median values in each group. Rank ANOVA indicates difference in groups based on ANOVA of rank values, and GT2 indicates comparison of means using Studentized Maximum Modulus test (SAS Institute, Inc. 1988). Significance levels: ns = not significant, (ns) = $0.1 > p > 0.05$, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. For numerical values of densities, refer to Table 7.7. "y" (yes) and "n" (no) indicate whether median value (or mean if median is zero) of category 1 > category 2 as shown. Dashes indicate that sample sizes were too small for meaningful analysis.

**Table 7.9**
Median (and mean ± SD) wading bird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

| | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|
| | Mangrove (n = 8) | | Non-mangrove (n = 14) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Small white egrets | 1.54 | 1.40 ± 1.04 | 0 | 1.40 ± 2.79 |
| White Ibis | 0 | 0.14 ± 0.40 | 0 | 0.16 ± 0.61 |
| Great Blue Heron | 0.12 | 0.18 ± 0.19 | 0 | 0.04 ± 0.07 |
| Little Blue Heron | 0 | 0.01 ± 0.02 | 0 | 0.01 ± 0.02 |
| Great Egret | 0.04 | 0.35 ± 0.78 | 0 | 0.01 ± 0.03 |
| Night-Herons | 0 | 0 | 0 | 0 |

| | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|
| | Mangrove (n = 12) | | Non-mangrove (n = 19) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Small white egrets | 0.07 | 0.16 ± 0.23 | 0 | 0.028 ± 0.063 |
| White Ibis | 0 | 0 | 0 | 0.01 ± 0.06 |
| Great Blue Heron | 0 | 0.01 ± 0.03 | 0 | 0.04 ± 0.07 |
| Little Blue Heron | 0 | 0.04 ± 0.14 | 0 | 0.002 ± 0.009 |
| Great Egret | 0 | 0.01 ± 0.02 | 0 | 0.03 ± 0.06 |
| Night-Herons | 0 | 0 | 0 | 0 |

| | Coastal areas with UPWELLING | | | |
|---|---|---|---|---|
| | Mudflat (n = 10) | | Non-mudflat (n = 12) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Small white egrets | 1.68 | 1.87 ± 1.97 | 0 | 1.00 ± 2.52 |
| White Ibis | 0 | 0.34 ± 0.77 | 0 | 0 |
| Great Blue Heron | 0.04 | 0.13 ± 0.19 | 0 | 0.06 ± 0.09 |
| Little Blue Heron | 0 | 0.007 ± 0.017 | 0 | 0.01 ± 0.02 |
| Great Egret | 0 | 0.27 ± 0.71 | 0 | 0.02 ± 0.03 |
| Night-Herons | 0 | 0 | 0 | 0 |

| | Coastal areas with NO UPWELLING | | | |
|---|---|---|---|---|
| | Mudflat (n = 3) | | Non-mudflat (n = 28) | |
| | Median | Mean ± SD | Median | Mean ± SD |
| Small white egrets | 0.15 | 0.11 ± 0.10 | 0 | 0.25 ± 0.53 |
| White Ibis | 0 | 0.09 ± 0.16 | 0 | 0 |
| Great Blue Heron | 0 | 0 | 0 | 0.03 ± 0.06 |
| Little Blue Heron | 0 | 0.16 ± 0.27 | 0 | 0.001 ± 0.008 |
| Great Egret | 0 | 0.02 ± 0.03 | 0 | 0.02 ± 0.05 |
| Night-Herons | 0 | 0 | 0 | 0 |

**Table 7.10**
Comparison of wading bird densities in areas of oceanic upwelling and non-upwelling for mangrove/non-mangrove and mudflat/non-mudflat habitats on the coast of Panama during surveys in January 1993

(a) Effects of upwelling on wading bird densities in mangrove/non-mangrove habitats

| | Mangrove habitats Upwelling (n = 8) vs. Non-upwelling (n = 12) | | | | | Non-mangrove habitats Upwelling (n = 14) vs. Non-upwelling (n = 19) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 |
| Small white egrets | y | ** | (ns) | * | * | y | ns | ns | ns | ns |
| White Ibis | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Great Blue Heron | y | *** | *** | *** | * | y | ns | ns | ns | ns |
| Little Blue Heron | n | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Great Egret | y | (ns) | ns | (ns) | ns | n | ns | ns | ns | ns |
| Night-Herons | – | – | – | – | – | – | – | – | – | – |

(b) Effects of upwelling on wading bird densities in mudflat/non-mudflat habitats

| | Mudflat habitats Upwelling (n = 10) vs. Non-upwelling (n = 3) | | | | | Non-mudflat habitats Upwelling (n = 12) vs. Non-upwelling (n = 28) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 | Upwelling > Non-upwelling | Wilcoxon | Median | Rank ANOVA | GT2 |
| Small white egrets | y | ns | (ns) | ns | ns | y | ns | ns | ns | ns |
| White Ibis | y | ns | ns | ns | ns | – | – | – | – | – |
| Great Blue Heron | y | (ns) | (ns) | * | * | y | ns | ns | ns | ns |
| Little Blue Heron | n | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Great Egret | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Night-Herons | – | – | – | – | – | – | – | – | – | – |

(c) Habitat (mangrove/non-mangrove) associations of wading birds within upwelling/non-upwelling zones

| | Areas with UPWELLING Mangrove (n = 8) vs. Non-mangrove (n = 14) | | | | | Areas with NO UPWELLING Mangrove (n = 12) vs. Non-mangrove (n = 19) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mangrove > Non-mangrove | Wilcoxon | Median | Rank ANOVA | GT2 | Mangrove > Non-mangrove | Wilcoxon | Median | Rank ANOVA | GT2 |
| Small white egrets | y | (ns) | (ns) | * | * | n | ns | ns | ns | ns |
| White Ibis | n | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Great Blue Heron | y | * | (ns) | * | * | n | ns | ns | ns | ns |
| Little Blue Heron | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Great Egret | y | * | * | * | * | n | ns | ns | ns | ns |
| Night-Herons | – | – | – | – | – | – | – | – | – | – |

(d) Habitat (mudflat/non-mudflat) associations of wading birds within upwelling/non-upwelling zones

| | Areas with UPWELLING Mudflat (n = 10) vs. Non-mudflat (n = 12) | | | | | Areas with NO UPWELLING Mudflat (n = 3) vs. Non-mudflat (n = 28) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mudflat > Non-mudflat | Wilcoxon | Median | Rank ANOVA | GT2 | Mudflat > Non-mudflat | Wilcoxon | Median | Rank ANOVA | GT2 |
| Small white egrets | y | * | * | * | * | n | ns | ns | ns | ns |
| White Ibis | y | ns | ns | ns | ns | y | ** | ** | ** | * |
| Great Blue Heron | y | ns | ns | ns | ns | y | ns | ns | ns | ns |
| Little Blue Heron | y | ns | ns | ns | ns | y | * | * | * | * |
| Great Egret | y | ns | ns | ns | ns | n | ns | ns | ns | ns |
| Night-Herons | – | – | – | – | – | – | – | – | – | – |

Statistical tests: Wilcoxon and Median tests compare median values in each group. Rank ANOVA indicates difference in groups based on ANOVA of rank values, and GT2 indicates comparison of means using Studentized Maximum Modulus test (SAS Institute, Inc. 1988). Significance levels: ns = not significant, (ns) = $0.1 > p > 0.05$, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. For numerical values of densities, refer to Table 7.9. "y" (yes) and "n" (no) indicate whether median value (or mean if median is zero) of category 1 > category 2 as shown. Dashes indicate that sample sizes were too small for meaningful analysis.

# *Chapter 8*
# Summary and conclusions

R.I.G. Morrison, R.W. Butler, R.K. Ross, and F.S. Delgado

## 8.1 Summary

Aerial surveys carried out during the Panamanian Shorebird Atlas Project successfully identified many of the key areas used by Nearctic shorebirds and other groups of waterbirds, including coastal seabirds, wading birds, and birds of prey, on the coast of Panama. Surveys to count populations of wintering birds were flown over both Pacific and Caribbean coastlines of Panama in January 1993. More restricted sets of surveys of the coast of the Golfo de Panama, between approximately the towns of Chitre, near Bahia de Parita, in the west, and Garachine, on the Golfo de San Miguel, in the east, were carried out to assess populations of birds present during the period of southward shorebird migration in October 1991 and during the late spring/northward migration period in late February 1988. The principal results of the project may be summarized as follows:

1. In January 1993, some 255 000 Nearctic shorebirds were counted on the Pacific and Caribbean coasts of Panama, with the vast majority (254 000, 99.8%) being found on the Pacific coast. Small shorebirds, mostly Western Sandpipers *Calidris mauri*, were numerically dominant, making up 236 000 (92.8%) of the total, with smaller numbers of medium-sized (12 300, 4.8%) and large (6200, 2.4%) shorebirds. Relative proportions and species compositions of the three size classes were different on the two coasts.

2. The most important areas for shorebirds in Panama occurred in the northern parts of the Golfo de Panama on the Pacific coast. The two coastal survey sectors east of Panama City held some 210 000 shorebirds (82.3% of the Panamanian total), including substantial proportions of the small (87.8%), medium-sized (18.7%), and large (37.6%) groups. This part of the coast contains very extensive mudflats of a variety of substrate types, as well as sandy beaches and stands of mangrove forests.

3. Other important areas around the Golfo de Panama included the mudflats and associated wetlands behind the shore of the Bahia de Parita, the flats and mangroves in Bahia de Chame, the flats west of Panama City, and the intertidal areas and mangroves around the Golfo de San Miguel in the east, especially those near Garachine.

4. Modest concentrations of Nearctic shorebirds were found in the Golfo de Montijo. Counts suggested that the area was relatively more important for medium-sized and large species than for small species.

5. Small to moderate concentrations of shorebirds occurred in the inlets and estuaries along the coastline of the Golfo de Montijo, and the sandy beaches in this area held the highest numbers of Sanderlings *Calidris alba* observed in Panama.

6. The most important areas for the limited numbers of Nearctic shorebirds counted on the Caribbean coast occurred in the northwest around the shores of the Laguna de Chiriqui (320, or 68.1%, of the Caribbean total of 470).

7. Some 25 900 coastal seabirds, wading birds, birds of prey, and other birds were counted during the surveys in January 1993. Coastal seabirds were the most numerous group, with some 23 400 (90.3% of the total) birds, followed by wading birds (2180, 8.4%), birds of prey (230, 0.9%), and other birds (93, 0.3%).

8. In general, coastal seabirds, wading birds, and birds of prey occurred in highest numbers and densities in the same regions of the coast favoured by Nearctic shorebirds (see 2–6 above).

9. The most important habitats for Nearctic shorebirds, coastal seabirds, wading birds, and birds of prey were mudflat/mangrove coastlines occurring in areas of oceanic upwelling in the Golfo de Panama. Such habitats develop where geomorphological, oceanographic, and other environmental conditions combine to produce extensive, muddy intertidal areas that are especially productive owing to nutrient input, and thus provide abundant food resources used by the birds. Such conditions occur in only a limited number of areas, emphasizing the importance of conservation in protecting key habitats.

10. In the Golfo de Panama, the highest totals of Nearctic shorebirds counted on aerial surveys occurred during the period of southward migration in October 1991, when over 369 000 shorebirds were recorded. This compared with totals of 185 000 Nearctic shorebirds during spring/northward migration in February 1988

and of 247 000 in the gulf during the wintering period surveys in January 1993.

11. Highest totals of many species of coastal seabirds and wading birds occurred during surveys of the Golfo de Panama in February 1988, compared with the winter and autumn surveys, at a time when coastal upwelling occurs in the gulf.

12. The wintering total of some 255 000 shorebirds in Panama may be compared with estimated wintering populations of 2.92 million for South America (Morrison and Ross 1989), 1.47 million for Mexico (Morrison et al. 1994b), 700 000 for coastal wetlands of the west coast of the United States and Canada (Page et al. 1992), and 119 000 for the central valley of California (Page et al. 1992). The Golfo de Panama appears to be of special importance for small sandpipers, mainly Western Sandpipers, the 1993 wintering population of some 231 000 being among the largest currently known for a single region on the Pacific coast of the Americas: this count may be compared with estimated wintering populations of 2700 from interior California (Shuford et al. 1994), 195 000 from coastal California (Page et al. 1992), 177 800 from Laguna Ojo de Liebre, Baja California, Mexico (Morrison et al. 1992), and over 434 000 from sites along the northwest Pacific coast of Mexico (Morrison et al. 1992, 1994b) (where the larger bay systems may hold up to several hundred thousand small shorebirds/peeps; Harrington 1994).

## 8.2 Conservational implications

The coast of the Golfo de Panama is clearly of international importance for Nearctic shorebirds, both as a wintering area and as a migration stopover area. The highest numbers and densities of shorebirds were found on the coastline east of Panama City in survey Sectors 61 and 62. These sectors held over 333 000 shorebirds in October 1991 and over 150 000 shorebirds in February 1988, in addition to the nearly 210 000 shorebirds counted during the winter surveys in January 1993. These numbers indicate that the area would qualify directly as an International reserve under the criteria of the Western Hemisphere Shorebird Reserve Network (WHSRN) (Morrison et al. 1995); when the likely "turnover" of birds moving through the area is considered, it is possible that the area would support 500 000 individual shorebirds, which would qualify the site as a Hemispheric reserve under WHSRN criteria. Designation of the area as a WHSRN reserve would serve both in helping to recognize the importance of the area and in providing conservational protection through this recognition.

Another method for providing recognition and protection of the area would be its designation as a Ramsar site. Panama signed the Ramsar Convention in November 1990 and to date has nominated three sites as wetlands of international importance (Ramsar Convention Bureau 1997). These sites include parts of the Golfo de Montijo (Veraguas), areas around Punta Patino (Darien), and San San – Pond Sak (Bocas del Toro). While the present surveys confirmed that significant numbers of shorebirds were found in the Golfo de Montijo and in the Ensenada de Garachine south of Punta Patino, the nomination of the coastline east of Panama City as a wetland of international importance under the Ramsar Convention would be entirely appropriate in recognizing its importance to populations of Nearctic shorebirds. The area exceeds criteria for recognition as a Ramsar site by a wide margin, as qualification is based on either a count of at least 20 000 birds or a count of greater than 1% of the flyway population of a species (Rose and Scott 1994). This numerical criterion is clearly met; although there is much uncertainty concerning sizes of shorebird populations in the Western Hemisphere, a count of over 300 000 small sandpipers is almost certain to exceed a 1% population level appropriate for Western Sandpipers, the principal species involved (Morrison et al. 1994a; Rose and Scott 1994).

The other areas in the Golfo de Panama that were important for shorebirds, including the Golfo de San Miguel, the coast between Punta de Chame and Panama City, and Bahia de Parita, all had maximum counts over the three surveys in the order of 14 000–15 000 shorebirds, somewhat less than the criterion for a WHSRN Regional reserve or a Ramsar site. Addition of totals of species of other coastal waterbirds brings the totals for these coastal sectors up to the 16 000–19 000 level. When likely turnover of birds moving through the area is taken into account, all these areas are likely to support more than 20 000 birds.

Counts in other parts of Panama, on both Pacific and Caribbean coasts, were available only from the surveys in January 1993, and totals were considerably less than 20 000 birds in areas that contained significant amounts of intertidal habitat, such as the Golfo de Montijo and the estuaries and inlets along the coastline of the Golfo de Chiriqui. Surveys in these areas were conducted mostly at high tide, when water had covered the intertidal zone and had flooded into mangroves or other vegetation along the shoreline. Further work in these areas to determine the extent to which shorebirds and other birds are present on intertidal habitats at lower stages of the tide and to determine whether such birds may fly to roosting areas away from the shoreline would be valuable. Surveys to determine the importance of the areas during migration periods, when counts were highest at other sites, would also be valuable.

The surveys have demonstrated that key habitats occur in areas where environmental conditions lead to the formation of suitable habitats (e.g., mudflats, sandflats, etc.) in areas of high biological productivity (e.g., where upwelling occurs in the Golfo de Panama). This emphasizes the importance of conserving such areas, as such conditions occur in only a limited number of areas, and apparently similar habitats in other areas will be unlikely to be able to support the same numbers of birds.

## 8.3 Literature cited

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# Appendices

**Appendix 1**
Linear densities (birds/km) of small shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Spotted Sandpiper | Sanderling | Unidentified small shorebirds | Total small shorebirds |
|---|---|---|---|---|---|
| **Caribbean coast** | | | | | |
| 1 | 16.5 | 0.12 | 0.00 | 0.00 | 0.12 |
| 2 | 15.8 | 0.06 | 0.00 | 0.00 | 0.06 |
| 3 | 23.9 | 0.04 | 0.00 | 0.00 | 0.04 |
| 4 | 19.1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 10.8 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 16.7 | 0.06 | 0.00 | 0.00 | 0.06 |
| 7 | 17.5 | 0.57 | 0.00 | 0.00 | 0.57 |
| 8 | 18.5 | 0.27 | 0.00 | 0.00 | 0.27 |
| 9 | 37.6 | 0.05 | 0.00 | 0.00 | 0.05 |
| 10 | 17.5 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 19.6 | 0.15 | 0.00 | 0.00 | 0.15 |
| 12 | 44.4 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | 44.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 48.6 | 0.08 | 0.00 | 0.00 | 0.08 |
| 15 | 26.0 | 0.31 | 0.00 | 0.00 | 0.31 |
| 16 | 32.1 | 0.16 | 0.47 | 0.00 | 0.62 |
| 17 | 39.4 | 0.36 | 0.00 | 0.00 | 0.36 |
| 18 | 32.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 26.4 | 0.04 | 0.00 | 0.00 | 0.04 |
| 20 | 39.0 | 0.00 | 1.15 | 0.00 | 1.15 |
| 21 | 30.2 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 21.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 21.1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | n.s. | | | | |
| 25 | 21.9 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26 | 20.9 | 0.05 | 0.00 | 0.00 | 0.05 |
| 27 | 22.5 | 0.09 | 0.00 | 0.00 | 0.09 |
| 28 | 54.1 | 0.06 | 0.02 | 0.00 | 0.07 |
| 29 | 28.7 | 0.03 | 0.00 | 0.00 | 0.03 |
| 30 | 18.4 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 22.4 | 0.00 | 0.00 | 0.00 | 0.00 |
| 32 | 25.5 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 29.5 | 0.03 | 0.00 | 0.00 | 0.03 |
| 34 | 30.1 | 0.00 | 0.00 | 1.00 | 1.00 |
| 35 | 37.4 | 0.00 | 0.00 | 0.00 | 0.00 |
| 36 | 21.9 | 0.14 | 0.00 | 0.00 | 0.14 |
| 37 | 40.5 | 0.00 | 0.00 | 0.00 | 0.00 |
| 38 | 11.8 | 0.00 | 0.00 | 0.00 | 0.00 |
| 39 | 23.0 | 0.00 | 0.00 | 0.00 | 0.00 |

*Continued*

**Appendix 1** *(cont'd)*
Linear densities (birds/km) of small shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Spotted Sandpiper | Sanderling | Unidentified small shorebirds | Total small shorebirds |
|---|---|---|---|---|---|
| 40 | 15.1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 41 | 14.3 | 0.07 | 0.00 | 0.00 | 0.07 |
| 42 | 12.2 | 0.00 | 0.00 | 0.00 | 0.00 |
| 43 | 15.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 44 | 25.9 | 0.00 | 0.00 | 0.00 | 0.00 |
| 45 | 22.3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 46 | 24.3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 47 | 19.8 | 0.00 | 0.00 | 0.00 | 0.00 |
| 48 | 21.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 49 | 21.7 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50 | n.s. | | | | |
| **Pacific coast** | | | | | |
| 51 | n.s. | | | | |
| 52 | 30.2 | 0.00 | 0.00 | 0.00 | 0.00 |
| 53 | 24.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 54 | 58.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 55 | 45.3 | 0.00 | 0.00 | 139.07 | 139.07 |
| 56 | 57.7 | 0.00 | 0.00 | 1.47 | 1.47 |
| 57 | 59.4 | 0.00 | 0.00 | 0.00 | 0.00 |
| 58 | 48.2 | 0.00 | 0.41 | 0.41 | 0.83 |
| 59 | 38.0 | 0.00 | 0.00 | 0.26 | 0.26 |
| 60 | 48.5 | 0.08 | 0.00 | 37.11 | 37.20 |
| 61 | 40.1 | 0.00 | 4.11 | 964.54 | 968.65 |
| 62 | 44.2 | 0.00 | 0.00 | 3763.46 | 3763.46 |
| 63 | n.s. | | | | |
| 64 | 30.9 | 0.00 | 0.00 | 216.83 | 216.83 |
| 65 | 40.7 | 0.00 | 0.00 | 171.99 | 171.99 |
| 66 | 30.8 | 0.00 | 0.32 | 0.00 | 0.32 |
| 67 | 23.9 | 0.00 | 0.00 | 0.00 | 0.00 |
| 68 | 24.6 | 0.00 | 1.02 | 0.00 | 1.02 |
| 69 | 37.4 | 0.00 | 0.00 | 13.24 | 13.24 |
| 70 | 31.9 | 0.00 | 0.00 | 108.87 | 108.87 |
| 71 | 12.3 | 0.00 | 0.00 | 12.20 | 12.20 |
| 72 | 24.9 | 0.00 | 1.49 | 2.01 | 3.49 |
| 73 | 21.9 | 0.05 | 0.37 | 0.00 | 0.41 |
| 74 | 22.6 | 0.00 | 0.04 | 0.00 | 0.04 |
| 75 | 15.9 | 0.06 | 0.00 | 0.00 | 0.06 |
| 76 | 26.5 | 0.00 | 0.00 | 0.00 | 0.00 |
| 77 | 18.2 | 0.00 | 4.67 | 0.33 | 5.00 |
| 78 | 19.3 | 0.00 | 0.00 | 0.00 | 0.00 |

*Continued*

**Appendix 1** *(cont'd)*
Linear densities (birds/km) of small shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Spotted Sandpiper | Sanderling | Unidentified small shorebirds | Total small shorebirds |
|---|---|---|---|---|---|
| 79 | 21.3 | 0.00 | 0.05 | 0.00 | 0.05 |
| 80 | 33.9 | 0.06 | 0.00 | 0.00 | 0.06 |
| 81 | 18.8 | 0.00 | 0.00 | 0.00 | 0.00 |
| 82 | 31.7 | 0.00 | 0.00 | 0.00 | 0.00 |
| 83 | 27.1 | 0.00 | 0.11 | 1.11 | 1.22 |
| 84 | 33.2 | 0.06 | 0.00 | 6.02 | 6.08 |
| 85 | 36.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 86 | 8.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 87 | 18.0 | 0.44 | 0.00 | 13.89 | 14.33 |
| 88 | 19.5 | 0.00 | 0.00 | 0.00 | 0.00 |
| 89 | 13.5 | 0.59 | 0.37 | 0.00 | 0.96 |
| 90 | 23.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 91 | 41.4 | 0.05 | 0.00 | 0.00 | 0.05 |
| 92 | 33.9 | 0.00 | 0.00 | 0.00 | 0.00 |
| 93 | 45.0 | 0.00 | 0.02 | 5.56 | 5.58 |
| 94 | 7.1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 95 | 31.7 | 0.06 | 0.00 | 0.00 | 0.06 |
| 96 | 35.2 | 0.00 | 9.12 | 0.00 | 9.12 |
| 97 | 18.4 | 0.00 | 0.00 | 0.00 | 0.00 |
| 98 | 18.7 | 0.05 | 1.60 | 0.00 | 1.66 |
| 99 | 51.9 | 0.04 | 1.64 | 1.83 | 3.51 |
| 100 | 52.8 | 0.00 | 0.00 | 0.00 | 0.00 |
| 101 | 51.5 | 0.04 | 0.00 | 0.00 | 0.04 |
| 102 | 25.0 | 0.00 | 0.40 | 12.24 | 12.64 |
| 103 | 26.9 | 0.00 | 0.00 | 99.81 | 99.81 |
| 104 | 44.4 | 0.00 | 3.22 | 6.53 | 9.75 |
| 105 | n.s. | | | | |
| 106 | 22.4 | 0.18 | 0.00 | 0.00 | 0.18 |
| 107 | n.s. | | | | |
| | Sum | Mean | Mean | Mean | Mean |
| 1–50 | 1220.3 | 0.06 | 0.03 | 0.02 | 0.11 |
| 51–107 | 1668.1 | 0.03 | 0.55 | 105.26 | 105.84 |
| 1–107 | 2888.4 | 0.04 | 0.30 | 55.25 | 55.59 |

n.s. = not surveyed

**Appendix 2**
Linear densities (birds/km) of medium-sized shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Black-bellied Plover | Ruddy Turnstone | Dowitchers | Yellowlegs | Unidentified medium-sized shorebirds | Total medium-sized shorebirds |
|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | |
| 1 | 16.5 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| 2 | 15.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 23.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 19.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 10.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 16.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 17.5 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |
| 8 | 18.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 37.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 17.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 19.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | 44.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | 44.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 48.6 | 0.06 | 0.00 | 0.00 | 0.00 | 0.45 | 0.51 |
| 15 | 26.0 | 0.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.58 |
| 16 | 32.1 | 0.56 | 1.81 | 0.00 | 0.00 | 0.00 | 2.37 |
| 17 | 39.4 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 |
| 18 | 32.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 26.4 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.11 |
| 20 | 39.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 30.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 21.6 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.05 |
| 23 | 21.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | n.s. | | | | | | |
| 25 | 21.9 | 0.05 | 0.14 | 0.00 | 0.00 | 0.00 | 0.18 |
| 26 | 20.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27 | 22.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 28 | 54.1 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |
| 29 | 28.7 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 30 | 18.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 22.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 32 | 25.5 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| 33 | 29.5 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 34 | 30.1 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 |
| 35 | 37.4 | 0.00 | 0.03 | 0.00 | 0.00 | 0.27 | 0.29 |
| 36 | 21.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 37 | 40.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 38 | 11.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 39 | 23.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 40 | 15.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 41 | 14.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 42 | 12.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 43 | 15.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 44 | 25.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 45 | 22.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 46 | 24.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 47 | 19.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 48 | 21.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 49 | 21.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50 | n.s. | | | | | | |
| **Pacific coast** | | | | | | | |
| 51 | n.s. | | | | | | |
| 52 | 30.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 53 | 24.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 54 | 58.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 55 | 45.3 | 0.04 | 0.00 | 2.21 | 0.00 | 3.75 | 6.00 |
| 56 | 57.7 | 0.00 | 0.17 | 0.00 | 0.00 | 2.60 | 2.77 |
| 57 | 59.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Continued*

**Appendix 2** *(cont'd)*
Linear densities (birds/km) of medium-sized shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Black-bellied Plover | Ruddy Turnstone | Dowitchers | Yellowlegs | Unidentified medium-sized shorebirds | Total medium-sized shorebirds |
|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 59 | 38.0 | 0.16 | 0.47 | 0.00 | 0.00 | 1.32 | 1.95 |
| 60 | 48.5 | 0.00 | 0.00 | 0.00 | 0.00 | 6.19 | 6.19 |
| 61 | 40.1 | 0.30 | 0.55 | 0.00 | 0.00 | 7.48 | 8.33 |
| 62 | 44.2 | 3.46 | 0.00 | 9.05 | 0.00 | 31.67 | 44.19 |
| 63 | n.s. | | | | | | |
| 64 | 30.9 | 0.00 | 0.00 | 0.00 | 0.00 | 1.29 | 1.29 |
| 65 | 40.7 | 0.00 | 0.00 | 0.00 | 0.00 | 19.66 | 19.66 |
| 66 | 30.8 | 0.00 | 0.00 | 0.00 | 0.00 | 3.25 | 3.25 |
| 67 | 23.9 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.04 |
| 68 | 24.6 | 0.00 | 0.00 | 0.00 | 0.04 | 0.85 | 0.89 |
| 69 | 37.4 | 0.00 | 0.00 | 3.88 | 0.00 | 0.80 | 4.68 |
| 70 | 31.9 | 1.00 | 0.00 | 55.20 | 0.06 | 136.36 | 192.63 |
| 71 | 12.3 | 0.00 | 0.00 | 28.46 | 0.00 | 0.00 | 28.46 |
| 72 | 24.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 73 | 21.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 74 | 22.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 |
| 75 | 15.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.13 |
| 76 | 26.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 77 | 18.2 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| 78 | 19.3 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| 79 | 21.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 80 | 33.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 81 | 18.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 82 | 31.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 83 | 27.1 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 |
| 84 | 33.2 | 0.03 | 0.00 | 9.64 | 0.00 | 2.11 | 11.78 |
| 85 | 36.6 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 86 | 8.6 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 |
| 87 | 18.0 | 0.00 | 1.67 | 0.00 | 0.00 | 8.33 | 10.00 |
| 88 | 19.5 | 0.00 | 4.10 | 0.00 | 0.00 | 0.00 | 4.10 |
| 89 | 13.5 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 |
| 90 | 23.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 91 | 41.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 92 | 33.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 93 | 45.0 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 |
| 94 | 7.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 95 | 31.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 96 | 35.2 | 0.14 | 0.31 | 0.00 | 0.00 | 0.00 | 0.45 |
| 97 | 18.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 98 | 18.7 | 0.27 | 0.00 | 0.00 | 0.00 | 0.32 | 0.59 |
| 99 | 51.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.39 |
| 100 | 52.8 | 1.33 | 0.00 | 0.00 | 0.00 | 0.00 | 1.33 |
| 101 | 51.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 102 | 25.0 | 0.00 | 1.20 | 0.00 | 0.00 | 0.20 | 1.40 |
| 103 | 26.9 | 0.00 | 0.00 | 0.00 | 0.00 | 17.47 | 17.47 |
| 104 | 44.4 | 1.37 | 0.09 | 0.00 | 0.00 | 0.09 | 1.55 |
| 105 | n.s. | | | | | | |
| 106 | 22.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 |
| 107 | n.s. | | | | | | |
| | Sum | Mean | Mean | Mean | Mean | Mean | Mean |
| 1–50 | 1220.3 | 0.05 | 0.04 | 0.00 | 0.00 | 0.02 | 0.11 |
| 51–107 | 1668.1 | 0.17 | 0.16 | 2.05 | 0.00 | 4.61 | 6.99 |
| 1–107 | 2888.4 | 0.11 | 0.11 | 1.07 | 0.00 | 2.43 | 3.72 |

n.s. = not surveyed

**Appendix 3**
Linear densities (birds/km) of large shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Whimbrel | Willet | American Oystercatcher | Black-necked Stilt | Unidentified large shorebirds | Total large shorebirds |
|---|---|---|---|---|---|---|---|
| **Caribbean coast** | | | | | | | |
| 1 | 16.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 15.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 23.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 19.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 10.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 16.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 17.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 18.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 37.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 17.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 19.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | 44.4 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| 13 | 44.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 48.6 | 1.69 | 0.93 | 0.00 | 0.00 | 0.00 | 2.61 |
| 15 | 26.0 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.12 |
| 16 | 32.1 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.09 |
| 17 | 39.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18 | 32.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 26.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20 | 39.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 30.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 21.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 21.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | n.s. | | | | | | |
| 25 | 21.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26 | 20.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27 | 22.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 28 | 54.1 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| 29 | 28.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 30 | 18.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 22.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 32 | 25.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 29.5 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 34 | 30.1 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 0.13 |
| 35 | 37.4 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 36 | 21.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 37 | 40.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 38 | 11.8 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| 39 | 23.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 40 | 15.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 41 | 14.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 42 | 12.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 43 | 15.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 44 | 25.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 45 | 22.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 46 | 24.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 47 | 19.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 48 | 21.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 49 | 21.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50 | n.s. | | | | | | |
| **Pacific coast** | | | | | | | |
| 51 | n.s. | | | | | | |
| 52 | 30.2 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.07 |
| 53 | 24.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 54 | 58.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 55 | 45.3 | 4.99 | 24.28 | 0.00 | 0.00 | 0.00 | 29.27 |
| 56 | 57.7 | 0.26 | 0.17 | 0.00 | 0.00 | 0.00 | 0.43 |
| 57 | 59.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Continued*

**Appendix 3** *(cont'd)*
Linear densities (birds/km) of large shorebirds counted during aerial surveys of the coast of Panama in January 1993

| Sector | Sector length (km) | Whimbrel | Willet | American Oystercatcher | Black-necked Stilt | Unidentified large shorebirds | Total large shorebirds |
|---|---|---|---|---|---|---|---|
| 58 | 48.2 | 0.10 | 4.56 | 0.00 | 0.00 | 0.00 | 4.67 |
| 59 | 38.0 | 2.26 | 2.16 | 0.00 | 0.00 | 0.00 | 4.42 |
| 60 | 48.5 | 1.86 | 4.49 | 0.00 | 0.00 | 0.82 | 7.18 |
| 61 | 40.1 | 8.53 | 15.09 | 1.00 | 0.02 | 0.00 | 24.64 |
| 62 | 44.2 | 3.67 | 26.88 | 0.00 | 0.00 | 0.00 | 30.54 |
| 63 | n.s. | | | | | | |
| 64 | 30.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 65 | 40.7 | 0.02 | 0.00 | 1.11 | 0.00 | 0.00 | 1.13 |
| 66 | 30.8 | 0.03 | 0.03 | 0.00 | 0.00 | 0.16 | 0.23 |
| 67 | 23.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 68 | 24.6 | 0.08 | 0.85 | 0.00 | 0.00 | 0.00 | 0.93 |
| 69 | 37.4 | 1.36 | 0.24 | 0.51 | 2.14 | 0.27 | 4.52 |
| 70 | 31.9 | 2.07 | 8.50 | 0.63 | 0.09 | 0.00 | 11.29 |
| 71 | 12.3 | 0.08 | 0.33 | 0.00 | 0.16 | 0.00 | 0.57 |
| 72 | 24.9 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.04 |
| 73 | 21.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 74 | 22.6 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.04 |
| 75 | 15.9 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| 76 | 26.5 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.04 |
| 77 | 18.2 | 1.21 | 0.82 | 0.00 | 0.00 | 0.00 | 2.03 |
| 78 | 19.3 | 0.05 | 0.10 | 0.00 | 0.00 | 0.00 | 0.16 |
| 79 | 21.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 80 | 33.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 81 | 18.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 82 | 31.7 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| 83 | 27.1 | 0.07 | 0.55 | 0.15 | 0.00 | 0.00 | 0.77 |
| 84 | 33.2 | 5.75 | 6.78 | 0.06 | 0.00 | 0.00 | 12.59 |
| 85 | 36.6 | 1.99 | 1.15 | 0.00 | 0.00 | 0.00 | 3.14 |
| 86 | 8.6 | 0.81 | 0.58 | 0.00 | 0.00 | 0.00 | 1.40 |
| 87 | 18.0 | 0.94 | 1.89 | 0.00 | 0.00 | 0.00 | 2.83 |
| 88 | 19.5 | 2.56 | 6.41 | 0.00 | 0.00 | 0.00 | 8.97 |
| 89 | 13.5 | 0.07 | 0.07 | 0.52 | 0.00 | 0.00 | 0.67 |
| 90 | 23.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 91 | 41.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 92 | 33.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 93 | 45.0 | 0.44 | 0.22 | 0.04 | 0.00 | 0.00 | 0.71 |
| 94 | 7.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 95 | 31.7 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 96 | 35.2 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 97 | 18.4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 98 | 18.7 | 1.02 | 0.00 | 0.00 | 0.00 | 0.00 | 1.02 |
| 99 | 51.9 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.04 |
| 100 | 52.8 | 0.09 | 1.23 | 0.00 | 0.00 | 0.00 | 1.33 |
| 101 | 51.5 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.08 |
| 102 | 25.0 | 0.08 | 0.08 | 0.08 | 0.00 | 0.00 | 0.24 |
| 103 | 26.9 | 0.56 | 0.74 | 0.37 | 0.00 | 0.00 | 1.67 |
| 104 | 44.4 | 0.11 | 0.05 | 0.00 | 0.00 | 0.00 | 0.16 |
| 105 | n.s. | | | | | | |
| 106 | 22.4 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.04 |
| 107 | n.s. | | | | | | |
| | Sum | Mean | Mean | Mean | Mean | Mean | Mean |
| 1–50 | 1220.3 | 0.04 | 0.03 | 0.00 | 0.00 | 0.00 | 0.07 |
| 51–107 | 1668.1 | 0.78 | 2.05 | 0.09 | 0.05 | 0.02 | 2.98 |
| 1–107 | 2888.4 | 0.43 | 1.09 | 0.04 | 0.02 | 0.01 | 1.60 |

n.s. = not surveyed